University of Alberta

New Derivative Instruments for Alberta Hog Producers

by

Donald Douglas Keith Bresee ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

in

Agricultural Economics

Department of Rural Economy

Edmonton, Alberta

Spring 1997

National Library
of Canada

Acquisitions and
Bibliographic Services

395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque nationale
du Canada

Acquisitions et
services bibliographiques

395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

Our file Notre référence

The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced with the author's permission.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-21156-8

Canada

University of Alberta

Library Release Form

Name of Author: Donald Douglas Keith Bresee
Title of Thesis: New Derivative Instruments for Alberta Hog Producers
Degree: Master of Science
Year this Degree Granted: 1997

Permission is hereby granted to the University of Alberta Library to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly, or scientific research purposes only.

The author reserves all other publication and other rights in association with the copyright in the thesis, and except as hereinbefore provided, neither the thesis nor any substantial potion thereof may be printed or otherwise reproduced in any material form whatever without the author's prior written permission.

Don Bresee
Don Bresee

Site 12 Box 7
R.R. #4
Ponoka, Alberta
T4J 1R4

Date February 25, 1997

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled New Derivative Instruments for Alberta Hog Producers by Donald Douglas Keith Bresee in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics.

Frank Novak

F. S. Novak, Supervisor

James Unterschultz

J. R. Unterschultz

W. C. Sauer

S. R. Jeffrey

Date Feb 14 / 97

Dedication

This project is dedicated to my parents, Keith and Donna. Everything I that I have and am I owe to you. Thank you so much.

Also, to my Tamara, thank you for giving me the ability to see things clearly and positively when the task seemed insurmountable. Your love and encouragement helped me see the light at the end of the tunnel.

Abstract

The objective of this study was to develop and analyze market-based window contracts in their ability to reduce revenue risk faced by hog producers. This study simulated a 350 sow farrow to finish hog farm for the period of 1981 to 1995 as part of the evaluation methodology. Several different types of risk management strategies were then incorporated into the hog farm's marketing program and analyzed in their ability to reduce risk.

This study shows that window contracts can be used by Alberta hog producers to reduce revenue risk. Routine window contracting outperformed routine hedging, selective hedging and routine forward contracting in terms of ability to reduce the variability of returns and the frequency of large losses to the producer without a large decrease in mean returns. The time period analyzed and type of window contract did, however, influence the relative performance of the window contracting strategies.

Acknowledgments

I would like to thank Frank and Jim for their patience in helping me with this project. Their input was both educational and, at times, humorous.

Jim C., Judy, Liz, Wendy and Dawn also deserve thanks for their assistance with gremlins in my computer and overall helpfulness.

Table of Contents

1. INTRODUCTION **1**

2. THE ALBERTA HOG INDUSTRY **4**

2.1 STRUCTURAL CHANGES IN THE ALBERTA HOG INDUSTRY 4
2.2 ALBERTA'S CONTRIBUTION TO CANADIAN HOG PRODUCTION 6
2.3 PORK TRADE BETWEEN ALBERTA AND THE U.S. 7
2.4 CHAPTER SUMMARY 7

3. BACKGROUND **9**

3.1 HISTORY OF GOVERNMENT SUPPORT PROGRAMS 9
3.1.1 FIDP *9*
3.1.2 NISA *10*
3.1.3 NTSP *10*
3.1.4 CBOP *11*
3.2 HOG PRODUCTION IN ALBERTA 12
3.2.1 Breeding and Genetics *12*
3.2.2 Weaning *13*
3.2.3 Feeding *13*
3.3 HOG MARKETING 14
3.4 HOG GRADING SYSTEM 15
3.5 CHAPTER SUMMARY 16

4. LITERATURE REVIEW **18**

4.1 RISK 18
4.1.1 Definition and Types of Risk *18*
4.1.2 Mean and Variance. *19*
4.1.3 Risky Decision Making *21*
4.1.4 E-V Model *21*
4.1.5 CML *22*
4.2 RISK MANAGEMENT INSTRUMENTS 23
4.2.1 Futures Contracts *23*
4.2.2 Option Contracts *32*
4.2.3 Forward Contracts *42*
4.2.4 Window Contracts *44*
4.3 PREVIOUS RESEARCH 49
4.4 CHAPTER SUMMARY 51

5. SIMULATION METHODOLOGY AND RESULTS **53**

5.1 METHODOLOGY 53
5.2 RESULTS 55
5.2.1 Cash Marketing *57*
5.2.2 Routine Hedging *62*
5.2.3 Selective Hedging *71*
5.2.4 Forward Contracting *83*
5.3 CHAPTER SUMMARY 87

6. WINDOW CONTRACTING **89**

6.1 ROUTINE WINDOW CONTRACTING USING CONFIDENCE INTERVALS TO SET WINDOWS 91
6.2 ROUTINE WINDOW CONTRACTING USING PROJECTED BREAK-EVEN PRICE TO SET WINDOWS ... 101
6.2.1 Minimum Price Contract *104*

6.3 SELECTIVE WINDOW CONTRACTING USING PROJECTED BREAK-EVEN PRICE TO SET WINDOWS 117
6.4 CHAPTER SUMMARY 121

7. CASE STUDY OF SELECT MARKETING STRATEGIES FROM 1990 TO 1995 123

8. DISCUSSION OF RESULTS FOR ALTERNATIVE RISK MEASURES 127

9. SUMMARY OF RESULTS AND CONCLUSIONS 129

9.1 RESULTS 129
9.2 CONCLUSIONS 133

10. BIBLIOGRAPHY 136

APPENDIX A. SIMULATION METHODOLOGY 141
APPENDIX B. DATA SOURCES 147
APPENDIX C. ARIMA AND INDEXED BASIS FORECASTING MODELS 151
APPENDIX D. 153

List of Tables

TABLE 1. ALBERTA HOG CARCASS GRADING/SETTLEMENT MATRIX 15
TABLE 2. CASH MARKETING REAL NET REVENUES IN 1995 DOLLARS - DOLLARS PER HEAD (1981-1995) 62
TABLE 3. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1981-1995) 66
TABLE 4. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1981-1995) 79
TABLE 5. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1981-1995) 86
TABLE 6. MAXIMUM AND MINIMUM WINDOW WIDTHS (1981-1995) 95
TABLE 7. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1981-1995) 97
TABLE 8. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1981-1995) 111
TABLE 9. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1981-1995) 119
TABLE 10. COMPARISON OF REAL NET REVENUES - DOLLARS PER HEAD (1990-1995) 124
TABLE 11. BREEDING STOCK REPLACEMENT RATES AND PIG DEATH LOSSES. 141
TABLE 12. FEEDER PIG FEEDING PROGRAM BY CATEGORY OF PIG 141
TABLE 13. WEEKLY PRICES AND COSTS 143
TABLE 14. FEED RATIONS 146
TABLE 15. TEST STATISTICS OF ARIMA (1,0,1)X(1,0,1) 151

List of Figures

FIGURE 1. ALBERTA INDEX 100 FINISHED HOG PRICE VOLATILITY 6
FIGURE 2. LIVE HOG BASIS SEASONALITY 27
FIGURE 3. PAYOFF FROM BUYING ONE PUT AND SELLING ONE CALL 47
FIGURE 4. COMBINED PAYOFF FROM PUT AND CALL OPTIONS 47
FIGURE 5. PAYOFF FROM CASH MARKETING 48
FIGURE 6. PAYOFF TO PRODUCER TAKING A WINDOW CONTRACT (ZERO BASIS RISK) 48
FIGURE 7. REAL COSTS AND REVENUES PER HEAD - CASH MARKETING (1995 DOLLARS) 57
FIGURE 8. REAL NET REVENUE PER HEAD - CASH MARKETING (1995 DOLLARS) 58
FIGURE 9. DISTRIBUTION OF REAL NET REVENUES - CASH MARKETING 58
FIGURE 10. VARIABILITY IN FEED GRAIN PRICES 60
FIGURE 11. ALBERTA INDEX 100 HOG PRICE 60
FIGURE 12. SEASONALITY IN NOMINAL ALBERTA FINISHED HOG PRICES 61
FIGURE 13. REAL NET REVENUE PER HEAD - ROUTINE HEDGING (1995 DOLLARS) 64
FIGURE 14. DISTRIBUTION OF REAL NET REVENUES - ROUTINE HEDGING 64
FIGURE 15. CHANGE IN REAL BASIS OVER HEDGING PERIOD (1995 DOLLARS) 68
FIGURE 16. REAL FORECASTED PROFIT (1995 DOLLARS) 68
FIGURE 17. DISTRIBUTION OF ROUTINE HEDGING TRADE PROFITS (1995 DOLLARS) 69
FIGURE 18. REAL POTENTIAL MARGIN REQUIREMENTS (1995 DOLLARS) 70
FIGURE 19. COST FORECASTING ACCURACY (NOMINAL DOLLARS) 75
FIGURE 20. ROOT MEAN SQUARE ERROR OF PRICE FORECASTING MODELS (NOMINAL DOLLARS PER KILOGRAM DRESSED) 77
FIGURE 21. REAL NET REVENUE PER HEAD WITH 10-10-15 SELECTIVE HEDGE (1995 DOLLARS) 81
FIGURE 22. DISTRIBUTION OF REAL NET REVENUES WITH 10-10-15 SELECTIVE HEDGE 81
FIGURE 23. CHANGE IN REAL BASIS OVER HEDGING PERIOD (1995 DOLLARS) 82
FIGURE 24. REAL NET REVENUE PER HEAD - ROUTINE FORWARD CONTRACTING (1995 DOLLARS) 85
FIGURE 25. DISTRIBUTION OF REAL NET REVENUES - ROUTINE FORWARD CONTRACTING 85
FIGURE 26. PRICE WINDOW ESTABLISHED USING 75% CONFIDENCE INTERVAL (1981-1995) 94
FIGURE 27. REAL NET REVENUES PER HEAD - ROUTINE 50% WINDOW CONTRACTING (NS) AND CASH MARKETING STRATEGIES (1995 DOLLARS) 100
FIGURE 28. COMPARISON OF DISTRIBUTIONS OF REAL NET REVENUES - ROUTINE 50% WINDOW CONTRACTING (NS) AND CASH MARKETING STRATEGIES 100
FIGURE 29. PAYOFF WHEN PUT AND CALL OPTIONS ARE IN-THE-MONEY (INVERTED WINDOW) 104
FIGURE 30. PAYOFF TO PRODUCER TAKING INVERTED WINDOW CONTRACT 104
FIGURE 31. PRICE WINDOW ESTABLISHED WITH PROJECTED BREAK-EVEN PRICE AS FLOOR (NOMINAL) 109
FIGURE 32. COST OF MINIMUM PRICE CONTRACT PER HEAD WITH GUARANTEED PRICE AT PROJECTED BREAK-EVEN PRICE (1995 DOLLARS) 109
FIGURE 33. PRICE WINDOW ESTABLISHED WITH PROJECTED BREAK-EVEN PRICE -$0.05/LB LIVEWEIGHT AS FLOOR (NOMINAL) 110
FIGURE 34. REAL NET REVENUE PER HEAD - BE/MPC(NS) AND CASH MARKETING STRATEGIES (1995 DOLLARS) 114
FIGURE 35. REAL NET REVENUE PER HEAD - MPC AND CASH MARKETING STRATEGIES (1995 DOLLARS) 115
FIGURE 36. COMPARISON OF DISTRIBUTIONS OF REAL NET REVENUES - BE/MPC(NS), MPC AND CASH MARKETING STRATEGIES (1995 DOLLARS) 116
FIGURE 37. E-V ANALYSIS OF SELECT MARKETING STRATEGIES 128

1. Introduction

Hog producers in Alberta have historically faced several challenging time periods when marketing their hogs. This is largely due to the volatile nature of the Alberta hog market, which is a major source of risk to Alberta hog producers and can seriously affect the income stability of enterprises producing hogs. The volatility of hog prices in Alberta necessitates a marketing program which allows for price risk to be managed in order to meet financial responsibilities.

Marketing tools such as forward contracts, futures contracts and options contracts are available to hog producers for the purpose of stabilizing hog farm incomes and reducing income variability. This study explored the potential benefits or shortcomings of using hog market-based derivative contracts for the purpose of price risk management from the beginning of 1981 to the end of 1995.

The objective of this study was to investigate the effectiveness of using different derivative contracts, such as hedging with futures contracts and window contracting, in reducing price risk. Hedging with futures contracts has widely been recognized as a strategy that can reduce price risk. Window contracts have been implemented in the United States and Manitoba, but their risk-reducing properties have not been investigated. Therefore, a need to explore the effectiveness of incorporating these derivative contracts into a structured marketing regime for the purpose of managing income stability was recognized and pursued.

Chapter 2 provides detail regarding the structure of the hog industry in Alberta, the relative contribution of Alberta pork production to Canadian pork production and the relationship between the Alberta and U.S. hog markets.

Chapter 3 details the two major government support programs that were historically available to Alberta hog producers, followed by a description of the manner in which hogs are produced and sold in Alberta.

Chapter 4 first provides a review of the basic concepts of risk and how risk can be measured. This is followed by a detailed background of the market-based derivative instruments that are available for reducing price risk, how these derivative instruments can be used to reduce risk, and some of the issues regarding using derivative market instruments for price risk management. Finally, results from studies relevant to this project are presented to provide insight toward the effectiveness of incorporating certain marketing strategies in reducing risk to hog operations.

Chapter 5 reveals the methodology used to generate a cost and revenue stream for a typical farrow to finish hog operation simulated from the beginning of 1981 to the end of 1995. This is followed by the results from incorporating marketing strategies such as cash marketing, routine hedging, selective hedging, and routine forward contracting into the hog operation's marketing strategy, and a discussion of the results of each marketing strategy.

Chapter 6 reviews the methodology used to establish window contracts. One type of contract was established on the basis of using the lower bounds of a confidence interval below the expected future hog price to establish the window floor price. The other type of contract was established using projected break-even costs minus a pre-specified target amount to establish the window floor. Chapter 6 analyzes the results of incorporating two routine minimum price contracting strategies and several types of window contracting strategies into the simulated hog farm's marketing program, followed by a discussion of these results.

Chapter 7 provides a case study which examines the risk-reducing properties of a select number of the previously examined strategies during the period 1990 to 1995. Although a marketing strategy may perform well over one time period, changes in market conditions may alter the effect of the marketing strategy over another time period. This provides motivation to examine more recent effectiveness of the marketing strategies being analyzed.

Chapter 8 provides an analysis of the various marketing strategies using the Mean-Variance (E-V) model and Capital Market Line (CML) criteria. In this chapter, the strategies are examined in their risk efficiency compared to cash marketing, and their risk-return tradeoff compared to financial markets.

Chapter 9 summarizes the results found from simulating the various marketing strategies examined in this study. This is followed by recommendations as to the optimal marketing strategy indicated by these results. Potential weaknesses of the study and directions for further research are then discussed.

2. The Alberta Hog Industry

This chapter provides a brief overview of the changes occurring in the Alberta hog industry over the past few decades, Alberta's contribution to Canadian hog production and the relationship between the Alberta and U.S. hog markets.

2.1 Structural Changes in the Alberta Hog Industry

The structure of the Alberta hog industry has changed drastically over the past several decades. Historically, Alberta hog production was mainly comprised of many small and privately owned operations. Most hog farms continue to be privately owned and operated but the trend of Alberta's hog industry has been towards larger scale production.

Prior to the 1970's, hog production was relatively inefficient in its use of resources compared to current production efficiency (Toma 1996). Genetic improvement programs and research on hog growth and feed requirements were largely undeveloped. As a result hogs were less efficient in feed conversion efficiency and took more days to reach finishing weight. The hog industry in Alberta has become highly focused on efficiency, with hog genetics displaying huge gains in reliable growth performance due to intensive research. Producers subsequently know with greater certainty the performance they will get from the animals produced in their herds.

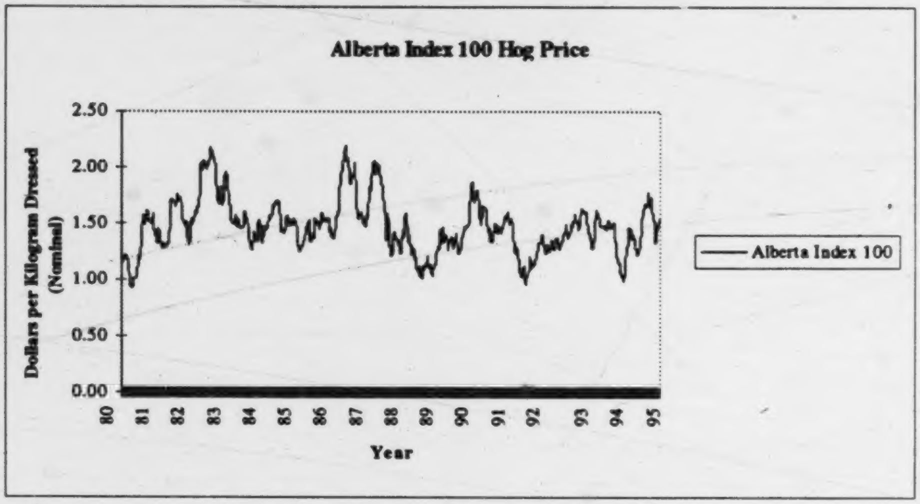
Improvements in the knowledge of hog performance has been accompanied by impressive gains in hog production technology and facilities. Prior to the 1970's, hogs farms required more labor and resources in production compared to current operations. Improvements in farm housing technology, veterinary knowledge, farrowing technology, and feeding technology have allowed a single unit of labor to produce more finished product than previously possible. Studies have indicated that returns to scale, increases in the demand for pork, technological advances being made in hog production, low feed costs, a solid swine industry infrastructure, relatively easy access to capital, and the progressive and cooperative nature of hog producers have led to the pork industry becoming more intensive and competitive (Dial and Morrison 1996). Thirty years ago, a hog farm housing fifty sows was considered large in size. Today single production units can house over one thousand sows. This has led to a huge expansion in hog farm capacities and correspondingly large gains in production efficiency. The strides made in hog production knowledge and capabilities have resulted in a significant restructuring of the Alberta hog industry in terms of farm sizes and numbers.

In Alberta, the number of hog farms reporting hog production has decreased dramatically over the last four decades while the number of pigs per farm has increased over this time period. The number of farms reporting hog production in Alberta has decreased from approximately 50,000 in 1951 to approximately 3,900 in 1995. Meanwhile, the average number of pigs per farm in Alberta grew from approximately 19 in 1951 to 500 in 1995 (Alberta Agriculture 1995). This trend has continued over recent times as well. The number of farms with pigs in Alberta decreased from approximately 6,000 in 1991 to a reported 3,900 in 1995, and the reported average number of pigs per farm in Alberta increased from 281 to 500 over that same time period (Alberta Agriculture 1995). It is clear that the Alberta hog industry has been very dynamic in its structure over the last four decades, and it seems that this trend will continue.

Hog production in Alberta is increasingly intensive. Producing hogs on a large scale requires significant amounts of initial capital for land, breeding stock and equipment. These investments are often financed through borrowing. As operations take on debt, it becomes increasingly important that hog producers identify the sources of risk in hog production and deal with those risks to remain in operation. Failure to manage price risk can result in significant losses and affect the operation's ability to meet its financial responsibilities.

The high degree of price volatility in the Alberta hog market is a major source of risk faced by hog producers. This volatility is caused by a high elasticity of supply coupled with a low elasticity of demand (Novak et al. 1992). Figure 1 provides a graphical presentation of the Alberta Index 100 hog price from 1980 to 1995.

Figure 1. Alberta Index 100 Finished Hog Price Volatility



This study explores several different risk management strategies in terms of their ability to reduce the price risk faced by hog producers while maintaining average returns.

2.2 Alberta's Contribution to Canadian Hog Production

As of 1995, Alberta was the third largest producer of hogs in Canada, following only Quebec and Ontario in the total number of pigs per province. In 1994, 1,211,000 tonnes of pork were produced in Canada and of that figure 169,000 tonnes (14%) were produced in Alberta (Alberta Agriculture 1994). In 1995, there were a reported 1,944,000 pigs on farms in Alberta. Alberta's share of Canadian hog production was a reported 16.5% in 1995 and has ranged from 27.6% in 1961 to 12.1% in 1981 (Alberta Agriculture 1995). Alberta is a significant contributor to total Canadian hog production.

2.3 Pork Trade between Alberta and the United States

Pork trade between the United States and Canada has historically been very active. Canada was a net importer of pork between 1974 and 1978, with the majority of these pork imports coming from the U.S.. Since 1978, Canada has exported more pork than it imports, with the bulk of those exports going to the U.S..

Since 1989, Alberta has formula priced hogs based primarily on U.S. cash prices (Toma 1996). The close proximity of Alberta to the large U.S. pork market and the high level of relatively free pork trade between these two regions suggests that Alberta pork prices are largely caused by U.S. pork prices (Meilke and Scally 1988). The integration of hog prices between the Alberta and the U.S. hog markets reinforces Alberta producers using U.S.-based hog market derivative instruments to manage price risk. From 1984 to 1989, hog prices were generated using an Ontario-based pricing formula. Prior to 1984, hog prices in Alberta were formulated on Ontario-based bidding prices (Toma 1996). Both pricing systems prior to 1989 may have affected the integration of U.S. and Alberta hog prices, thus affecting the effectiveness of using U.S.-based hog derivative instruments in managing risk.

2.4 Chapter Summary

It is apparent that several factors must come into consideration when marketing hogs in Alberta. Alberta hog prices are highly volatile, suggesting that marketing hogs without a strategy designed to control price risk can result in a highly variable income stream. Incorporating a risk management strategy into a typical hog operation may improve income stability, maintain or increase average income, and reduce or eliminate those time periods where large losses are incurred.

It has been suggested that Alberta hog prices are caused by U.S. hog prices (Meilke and Scally 1988). This is useful because the primary hog price discovery mechanism, hog futures markets, are not traded in Canada but are traded in the U.S.. Canadian hog producers have access to these markets and can use them in a marketing program. Prior to 1989, the linkage between the U.S. and Alberta hog prices may have been somewhat weaker than it currently is, which could have affected the usefulness of these derivative instruments to hog producers.

Chapter 3 provides background information on important government support programs historically available to hog producers, an overview of how hogs are produced on a typical farrow to finish hog operation, and how finished hogs are priced and sold in Alberta. The purpose of the following chapter is to reinforce the methodology used in simulating a farrow to finish hog operation for the purpose of evaluating alternative marketing strategies in reducing risk.

3. Background

The first section of this chapter provides an overview of the major government programs historically offered to Alberta hog producers. This is followed by sections illustrating how hogs are produced, marketed and priced in Alberta.

3.1 History of Government Support Programs

Hog farmers in Alberta have had several different government support programs available to them for the purpose of price risk management. The four most recent and important programs available are the Alberta Farm Income Disaster Program (FIDP), the Net Income Stabilization Account (NISA), the National Tripartite Stabilization Plan (NTSP) and the Crow Benefit Offset Program (CBOP).

3.1.1 FIDP

The FIDP provides stability against fluctuations in a farm's program margin. The program provides support to the amount of 70% of the three year average of historical program margin minus current program margin. Defining current program margin as:

$$PM_t = Revenue_t - Expenses_t \qquad \text{(Equation 1)}$$

where: PM_t = program margin in current year

and last years program margin as:

$$PM_{t-1} = Revenue_{t-1} - Expenses_{t-1} \qquad \text{(Equation 2)}$$

the program provides assistance in the following manner:

$$Payment_t = Max[(0.70*((PM_{t-1} + PM_{t-2} + PM_{t-3})/3)) - PM_t, 0] \qquad \text{(Equation 3)}$$

and if $PM_t < 0$, then $PM_t = 0$

Although this program is currently being offered through the Alberta Financial Services Corporation to Alberta farmers, the effects of this program are not incorporated into this study.

3.1.2 NISA

The NISA program provides assistance to farmers through the establishment of an account in which a farmer can make deposits in profitable years and withdrawals in non-profitable years. Federal and Provincial Governments also contribute to this account during periods in which the farmer makes a deposit. This provides the farmer with an instrument in which to acquire funds in times of need.

Because the NISA program was not offered for most of the time period analyzed, this study does not incorporate the effects of the NISA program.

3.1.3 NTSP

The NTSP was a red meats stabilization program implemented on July 1, 1986. The program was designed to stabilize prices faced by red meats producers. The cost of the program was shared equally by three parties, the federal and provincial governments and producers participating in the program (Tan 1988).

The NTSP paid hog producers according to a support price which was calculated using national average cash costs per quarter of a 130 sow farrow to finish hog operation compared to the historical five year average cash costs and hog price of that same quarter. The support level was calculated as a percentage (93-95%) of the difference between the 5 year average cash costs and hog price plus the cash costs of the current quarter (Tan 1988). If the support level exceeded the national weighted average market price, the producer received the difference between the support level and national weighted market price.

The following equations describe the methodology used to calculate support levels and payments to hog producers (Novak et al. 1992):

$$S = CC + Factor(FASP - FAC) \qquad \text{(Equation 4)}$$

$$P = S - NMP \qquad \text{(Equation 5)}$$

where: S = support level
CC = cash cost per head per quarter
$Factor$ = guaranteed margin percentage (93-95%)
$FASP$ = five year moving average of price for that quarter
FAC = five year moving average of cost for that quarter
P = payment (if $S - NMP > 0$)
NMP = national weighted average market price

The large portion of the NTSP premiums paid by the Federal government led to a conflict between the NTSP and U.S. trade policy which forbids government subsidization that can be shown to harm a U.S. industry (Benson et al. 1994). As a result, in April of 1994 the NTSP program was terminated (Alberta Agriculture 1996).

Although studies indicate that the NTSP increased returns and reduced the variability of returns of Alberta hog growers (Novak et al. 1992), this study does not include NTSP payments in its analysis as the program is no longer available to Alberta hog producers.

3.1.4 CBOP

The CBOP, formerly known as the Alberta Feed Grain Market Adjustment Program, was established to increase the competitiveness of local feed grains with grains being subsidized under the Western Grain Transportation Act. The Alberta government enacted this program and subsidized the cost of local feed grains to livestock producers (Novak and Viney 1995). The program subsidized the cost of these feed grains on a pre-established dollar per tonne basis. Payments for feed wheat and barley were $21.00 per tonne from September, 1985 to June 1987, $13.00 per tonne from July, 1987 to August, 1989, and $10.00 per tonne from September, 1989 to March 31, 1994.

This study includes the effects of CBOP payments to producers. The CBOP program is included through the calculation of a net barley and wheat price to producers when subsidization of feed grains occurred.

3.2 Hog Production in Alberta

Three main types of hog operations exist in Alberta. Two of these are farrow to weaner operations and feeder operations. Farrow to weaner operations sell piglets at approximately 16 to 20 kilograms. Feeder operations purchase these weaner pigs and feed them to slaughter weight. The third type of operation, which is modeled in this study, is the farrow to finish operation.

Farrow to finish operations generally keep male and female breeding stock and produce their own finished pigs. A 1991 census of hogs farms reported 4,034 farms with sows for breeding and bred gilts (Statistics Canada 1991). A larger size farrow to finish operation will house several hundred or thousand sows and market approximately 20 pigs per sow per year. In Alberta, farrowing typically occurs in a closed facility, therefore producers are able to farrow their sows throughout the year. As a result, farrow to finish hog operations typically market hogs year-round.

3.2.1 Breeding and Genetics

Many different breeding techniques are available for hog producers to breed sows.

Artificial insemination has become a popular alternative to the traditional method of purchasing boars to inseminate the herd. Although many farrow to finish operations incorporate artificial insemination into their breeding programs, boars are often kept in the operation for cleanup breeding or to tease females in order to decrease time to breeding (Alberta Agriculture 1992). The sow to boar ratio of farrow to finish farms will thus vary according to the breeding program. Replacement females are selected from within the herd and/or purchased on the open market.

The rates of gain and feed conversions of feeder pigs are largely a function of the quality of genetics of the breeding stock, although the intensity of the feeding program affects grower performance as well. Variation in performance between farms can be observed due to variations in the genetic and feeding programs used. Some operations are able to achieve a farrow to finish period of less than 160 days, but a typical efficient operation finishes a pig in the 175 day range. With a weaning age of approximately 21 days, this translates into approximately 154 days on feed.

3.2.2 Weaning

The weight at which pigs are weaned also varies between operations. Intensive operations typically wean piglets at a weight of 7 to 8 kilograms (Alberta Agriculture 1992). Depending on post birth growth rates, this translates into an approximate weaning age of two to three weeks.

3.2.3 Feeding

Feeding programs also vary between operations. A typical operation will feed one ration to gestating sows and boars, another ration to lactating sows, and two to four different rations to grower pigs. Due to the lactating sow's greater nutritional requirements, dry sow and boar rations usually consist of lower protein, digestible energy, and micronutrient levels (Gowans 1996).

Upon weaning, piglets receive a high energy and protein starter ration until they reach a weight of 20 to 27 kilograms. When the piglets reach this weight they are moved to rations that are lower in digestible energy and crude protein content until they reach finishing weight (Alberta Agriculture 1992).

Hogs are normally marketed at a finishing weight of 105 to 110 kilograms liveweight. At this time they are sold to a packing plant.

3.3 Hog Marketing

Prior to December 2, 1996, the period which is encompassed in this study, Alberta hog finishers were required to market all their hogs through the Alberta Pork Producers Development Corporation (APPDC). Under this arrangement the producer selected the point at which he or she wished to offer the hogs to the APPDC. Once this had been done the APPDC offered the hogs for sale to potential buyers. When a buyer was found for the hogs, the APPDC notified the producer as to the buyer and location of the buyer, the price received for the hogs and other specifics relative to the exchange (Toma 1996).

Producers are no longer required to market their hogs through the APPDC, although they have the option to do so. As a result of the recent changes, producers are able to negotiate contracts directly with potential buyers. Many of the contracts developed in this study were not offered by the APPDC. Producers now, however, have flexibility in the manner in which they wish to sell their hogs. This flexibility permits hog buyers to offer contracts developed in this study to producers.

3.4 Hog Grading System

A hog is priced in Alberta according to its dressed weight and percent lean yield. The two grading grids currently offered by Fletcher's Fine Foods Ltd. (1996) are as follows:

Table 1. Alberta Hog Carcass Grading/Settlement Matrix

Standard Hog Carcass Grading Matrix

Yield Class No.	Lean Yield %	< 68 kg	68-72.9 kg	73-77.9 kg	78-82.9 kg	83-87.9 kg	88-92.9 kg	93-97.9 kg	98-102.9 kg	> 103 kg
1	> 64.29	10	80	100	112	114	114	113	100	81
2	63.0-64.29	10	80	99	111	113	113	112	98	81
3	61.8-62.99	10	80	98	110	113	113	110	95	81
4	60.7-61.79	10	80	97	108	112	112	108	82	81
5	59.6-60.69	10	80	96	107	111	110	106	82	81
6	58.6-59.59	10	80	95	106	109	108	103	82	81
7	57.7-58.59	10	80	93	103	107	106	100	82	81
8	56.9-57.69	10	80	91	101	103	102	98	82	81
9	56.1-56.89	10	80	91	99	101	100	96	82	81
10	< 56.10	10	80	91	96	99	98	94	82	81

Specialty Hog Carcass Grading/Settlement Matrix

Yield Class No.	Lean Yield %	55-71.9 kg	72-76.9 kg	77-83.9 kg	84-88.9 kg	89-93.9 kg	94-98.9 kg	99-102.9 kg	> 103 kg
1	> 64.29	80	111	114	113	106	100	81	81
2	63.0-64.29	80	110	113	112	105	100	81	81
3	61.8-62.99	80	110	113	112	105	100	81	81
4	60.7-61.79	80	109	112	111	104	100	81	81
5	59.6-60.69	80	108	111	110	103	100	81	81
6	58.6-59.59	80	107	109	108	102	90	81	81
7	57.7-58.59	80	104	107	106	100	90	81	81
8	56.9-57.69	80	98	101	100	100	90	81	81
9	56.1-56.89	80	91	98	96	95	90	81	81
10	< 56.10	80	85	96	90	90	90	81	81

Once grading has been completed on a slaughtered hog, the effective price received by the producer can be expressed as the following:

$$Price\ (\$/kg\ dressed) = Alberta\ Index\ 100\ hog\ price * Index \qquad \text{(Equation 6)}$$

where: *Alberta Index 100* = dollars per kilogram dressed
Index = hog indexing grade

and the revenue generated from the sale of the hog can be expressed as:

$$Revenue\ (\$/hog) = Price * Outwt * Dressing\ percentage \qquad \text{(Equation 7)}$$

where: *Outwt*=finishing weight in kilograms liveweight

Any selling or grading fees are charged on a per hog basis, and are deducted after the sale has been finalized.

3.5 Chapter Summary

Chapter 3 first provided a review of four major government support programs offered to hog producers, the FIDP, NISA, NTSP and the CBOP. The FIDP and NISA were not offered to producers over most of the time period analyzed, and were therefore not included in this study. The NTSP was found to reduce risk and increase returns to hog producers (Novak et al. 1992), but was not included in this study. This conceptually reinforces the notion that marketing strategies other than continual cash marketing may increase incomes and/or income stability. The CBOP has also been terminated, but the feed cost-reducing properties of this program were included in the simulation analysis in following sections. This was followed by a review of how hogs are typically produced and marketed in Alberta, and the way in which the hog price received by producers is determined. These sections provide support to the methodology used in simulating a farrow to finish hog operation for the purpose of analyzing the effects of different marketing strategies on returns.

Chapter 4 investigates the theories relevant to the subject of risk and the methods available to measure risk. This is followed by sections providing information regarding some of the hog market derivative instruments available to hog producers for the purpose of reducing risk, and issues concerning potential detriments of using these derivative instruments. Chapter 4 provides a framework in which the different marketing alternatives simulated in this study were analyzed.

4. Literature Review

Chapter 4 provides a review of theory and literature relating to risk and how risk can be measured. This is followed by a discussion on the relevant hog market derivative instruments that can be used by Alberta hog producers in their marketing program, and how those instruments can be incorporated into a marketing program. Also presented in this chapter are some of the issues regarding the use of these derivative instruments and results from other studies which have explored the effectiveness of some of these derivative instruments in reducing risk to hog producers.

4.1 Risk

4.1.1 Definition and Types of Risk

Hog producers face two main types of risk: production risk and price risk (Bauer 1988). Production risk is associated with the variability in the quantity or quality of the good being produced. This risk is caused by unpredicted changes in factors influencing production such as mortality rates, morbidity rates and feed conversion. Production risk can be managed through improvements in husbandry skills and technological improvements in production.

Price risk is the risk associated with the variability of returns to an operation due to unpredicted changes in output or input prices. Price risk can be managed through the use of several different investment strategies such as diversification into other activities or investments, or investing in market derivatives (Brealy et al. 1992).

For many farmers, diversification with stocks or other investments is not a practical alternative due to a limiting amount of capital that may be applied to alternative investments and lifestyle concerns (Novak and Viney 1994). As a result, the use of commodity derivative instruments, such as futures contracts, for the purpose of managing price risk has been widely studied and supported.

4.1.2 Mean and Variance.

A distribution of returns represents the frequency of observing returns of different magnitudes over time. Two measures used to describe a distribution of returns are the mean of the distribution and the variance of the distribution. The mean of a distribution represents the statistical average of all returns in a return series. The variance of a distribution represents how dispersed or spread out the returns are around the mean of the return series. The standard deviation of a return series is the square root of its variance.

The mean of a series ($\overline{X}$) is calculated as:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n} \qquad \text{(Equation 8)}$$

The variance of a series (σ^2) is calculated as:

$$\sigma^2 = \frac{\sum_{i=1}^{n} (X_i - \overline{X})}{n-1} \qquad \text{(Equation 9)}$$

The standard deviation of a series (σ) is calculated as:

$$\sigma = \sqrt{\sigma^2} \qquad \text{(Equation 10)}$$

This study uses forecasting techniques in developing some marketing strategies. Risk in forecasting performance can be evaluated using E-V analysis through the Mean Square Error (MSE) and Root Mean Square Error (RMSE) statistics.

Given a predicted value of a return $\hat{X}_t$ at time t, and the observed return value X_t at time t :

$$MSE = \frac{\sum_{t=1}^{n}(\hat{X}_t - X_t)^2}{n-1} \qquad \text{(Equation 11)}$$

and

$$RMSE = \sqrt{MSE} \qquad \text{(Equation 12)}$$

This study uses standard deviation and root mean square error as measures of risk. Because the standard deviation and RMSE measures are in the same units as the series analyzed, they are a more convenient measure of return dispersion about the mean. Using standard deviation or RMSE in the place of variance and MSE, respectively, does not violate the condition of E-V decision making analysis. This is because standard deviation and RMSE are positive monotonic transformations of variance and MSE, respectively (Young 1984).

Unterschultz (1991) used standard deviation, MSE and RMSE as measures of risk. Novak et al. (1992) used RMSE as a risk measure. Novak and Viney (1995) used both standard deviation and RMSE as risk measures. Leuthold and Mokler (1980), Kenyon and Clay (1987) and Ditsch and Leuthold (1996) used variance as a measure of risk.

4.1.3 Risky Decision Making

Several different models exist to evaluate marketing choices and investment decisions in a risky environment. The models used in this study are the safety-first and Mean-Variance (E-V) models and the Capital Market Line (CML).

According to Young (1984), three classes of decision rules exist to evaluate a set of risky alternatives. The first class contains decision rules that require no probability information, the second class contains safety first rules and the third class deals with expected utility maximization.

Decision rules that require no probability information are criticized as being loosely, if at all, connected with the concept of risk because they ignore information regarding the probabilities of different events occurring (Young 1984). As a result, rules that require no probability information were not used in analysis.

Safety-first decision making rules rank goals according to priority. A goal of second highest priority will not be sought after until the goal with the highest priority is attained (Robison et al. 1984). Under safety-first decision making criteria, it is assumed that minimizing the probability of a disastrous outcome occurring receives the highest priority. In the safety-first framework, the purpose of risk management is to truncate the lower end of the distribution of returns. In other words, the intent is to decrease the number of times a return below a certain value is observed. This study uses the safety-first criterion as one method of evaluating different marketing alternatives.

4.1.4 E-V Model

The expected utility model (EUM) combines utility theory and risk to evaluate decision making under different risk profiles and choices. If the axioms of the EUM are met (Barry 1984) an optimal risky choice in the presence of a set of risky choices can be found through the maximization of expected utility. A special case of the EUM is the Mean-Variance (E-V) model. The E-V model assumes that an individual's utility function is quadratic or that profits are normally distributed. These two assumptions allow for risky choices to be compared through their mean and variance statistics (Young 1984).

Using E-V analysis and the assumptions contained within it, a set of risky choices can be narrowed into a risk efficient set of choices. Assuming an individual is always risk averse (always prefers less risk to more risk), a risk efficient set of choices can be found through the following methodology. Assume there are two possible outcome distributions, A and B. Outcome A with mean E_A and variance V_A will be preferred to (dominate) outcome B with mean E_B and variance V_B if $E_A \geq E_B$ and $V_A \leq V_B$, and one of the two inequalities is strict (Young 1984).

4.1.5 CML

The capital market line (CML) is a tool that can be used to evaluate the outcomes of different investment or marketing decisions. This line can be used in accordance with the E-V criteria to analyze the risk and return trade-off of different investment portfolios compared to a risk free investment. The CML plots the risk and return tradeoff of a risk-free asset such as the 90 day treasury bill and a diversified and efficient portfolio of assets. The slope of the capital market line represents this tradeoff (Ross et al. 1992). Brealey et al. (1992) present data from 1926 to 1988 on treasury bill rates and common stocks that would yield a CML slope of 0.49. This study assumes a capital market line slope of 0.4, which is consistent with other studies incorporating more current market data. The capital market line can thus be shifted to intercept the risk and return data point of a base marketing strategy as long as the slope of the line is preserved in order to analyze risks and returns of other marketing strategies compared to the base marketing strategy. This procedure allows for alternative marketing strategies to be compared to the base case using the market based price of risk.

4.2 Risk Management Instruments

4.2.1 Futures Contracts

A futures contract is a market traded instrument that can be used to manage price risk. It is a legally binding agreement between two parties to exchange an asset of defined quality and quantity (or its cash value) at a specific date and location in the future for a predetermined price. Selling (going short) a futures contract gives an investor the obligation to deliver the asset at a future date under terms of the contract. Buying (going long) a futures contract gives an investor the obligation to purchase the asset at a future date under terms of the contract.

Although a futures contract is a contract to buy or sell a commodity at the maturity date of the contract, these contracts are typically offset to avoid the physical exchange of goods. A short position in the futures market can be offset by going long a corresponding number of futures contracts, liquidating the investor from any position in the futures market. Conversely, a long position in the futures market can be offset by selling a corresponding number of futures contracts. The gain or loss from trading a futures contract is the difference between the selling and buying price of the contract multiplied by the quantity of commodity traded in the contract.

If a short futures contract is not offset prior to its maturity, the asset must be delivered through a delivery mechanism provided by the exchange. The potential for arbitrage ensures that the futures market price and cash price of the commodity differ only by costs of delivery upon maturity of the futures contract. This linking of the futures and cash market prices at maturity of the futures contract is called convergence.

The live hog futures contract, traded on the Chicago Mercantile Exchange, has been the primary price discovery mechanism for finished North American hogs. It is also the futures contract used to hedge finishing hogs. This contract calls for the delivery of 40,000 pounds of liveweight hogs on one of seven different delivery months being traded. The seven delivery months in which live hog futures are traded are; February, April, June, July, August, October, and December. The live hog futures contracts was recently changed to reflect a carcass-based price and these contracts are now cash settled. These changes did not occur over the time period examined in this study and as a result futures market prices were reported in U.S. dollars per pound liveweight.

There are transaction costs associated with trading hog futures contracts. Brokerage firms typically charge a fee of 50 to 100 dollars per round turn trade, depending on other services offered in conjunction with performing the trade. Initial margin requirements also need to be posted by the investor with the broker, and a minimum margin requirement must be maintained in the investors account. Margin requirements are discussed in more detail under "Margin or Performance Bonds".

4.2.1.1 Basis

The difference between the price of a futures contract and cash price of a commodity on a particular date and a particular location is referred to as the basis. The equation used to determined the basis is:

$$Basis_{\$CDN} = Futures_{\$CDN} - Cash_{\$CDN} \qquad \text{(Equation 13)}$$

where: $\$CDN$ = all prices and resulting basis defined in Canadian currency

The live hog futures price is quoted in U.S. dollars and therefore must be converted by the current Canada/U.S. exchange rate to calculate a relevant basis for Alberta hog producers. This study calculates basis using Equation 13 and basis is thus expressed as a positive number.

More than one live hog basis will exist on a given day, as several live hog futures contracts are traded at a time. The relevant basis to a producer is the current futures price in the month nearest but not prior to the anticipated time of sale of the physical hogs, minus the current cash price at the location where the producer plans to sell the hogs. For example a producer planning to sell a pen of hogs in January would use the February live hogs contract rather than the January live hogs contract. The reason for using a futures contract that does not expire prior to the anticipated time of sale is that hogs would not be protected for the period after the contract expires to the date of sale when using a contract that expires too early. It is also recommended that a hedge be closed out several days prior to maturity of a futures contract because of unpredictable basis behavior shortly prior to contract maturity.

Many different factors affect the absolute size of the basis (discussed under "Basis Risk"). A change in the costs of delivering the asset at maturity of the futures contract will change the magnitude of the basis, as will a change in the Canada/U.S. exchange rate as the futures price is quoted in U.S. dollars. A wide (weak) basis occurs when the difference in price between the cash and futures market is large in absolute value, while a narrow (strong) basis occurs when this price difference is small in absolute value. An important factor when viewing the basis at a particular time of year is basis seasonality, which is discussed under the "Basis Risk" section.

4.2.1.2 Hedging

Futures markets can be used by producers to transfer price risk to basis risk. This is done by hedging the physical product with futures contracts for the period when the product is to be sold.

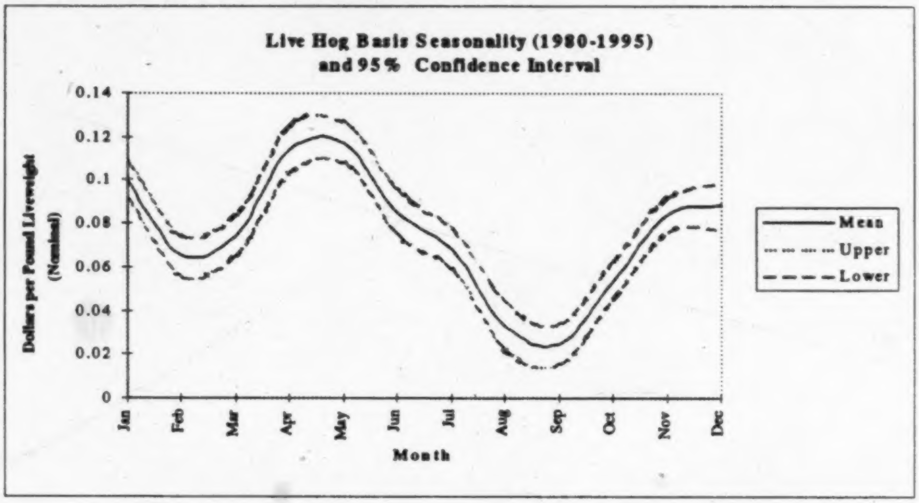
Hedging entails selling futures contracts so that decreases in the price of the cash commodity are offset by corresponding gains on the futures contracts. The futures contract to be used should be the one maturing nearest, but not prior, to the sale of the commodity. If a producer is fully hedged (i.e sells a volume of commodity on the futures equal to the volume of physical commodity to be sold) and the futures and cash markets exhibit perfect correlation, basis risk is zero. Assuming a constant basis, once a hedge has been placed, the price received for the commodity has been locked in. Futures market gains or losses will offset losses or gains, respectively, in the cash commodity over the span of the hedge. Unfortunately, the basis is not constant and as a result a hedge is susceptible to basis risk. If the basis narrows over the period of the hedge, the producer will gain in net profit from the hedge while the opposite occurs if the basis widens.

4.2.1.3 Basis Risk

Basis risk resides in unpredicted changes in the relative difference of the futures and cash price over the time period of the hedge. If the futures and cash markets do not exhibit perfect correlation, basis risk is not zero. Much research has been carried out on identifying sources of basis risk, such as seasonality in cash prices and market inefficiency.

Figure 2 demonstrates the seasonal nature of the nearby live hog basis. Seasonality in the basis is probably caused by seasonal patterns in output affecting the cash market and thus the nearby basis. Producers in southern states of the U.S. sell a high volume of hogs during the spring months and fewer hogs during the fall months due to outdoor farrowing. This tends to decrease cash prices in the spring months and increase cash prices in the fall months. As a result, the basis is usually wider in the spring months and narrower in the fall months.

Figure 2. Live Hog Basis Seasonality



The mean and standard deviation of the live hog basis from 1980 to 1995 were 0.0757 and 0.0483 dollars per pound liveweight, respectively. The coefficient for the seasonal autoregressive variable in the ARIMA (1,0,1) X (1,0,1) basis forecasting model tested positive for significance, indicating that basis seasonality is significant with a confidence level of 95% (Appendix C).

4.2.1.4 Exchange Rate Risk

Changes in the exchange rate over the period of a hedge are also a source of risk to a hedger because the live hog futures contract must be converted to Canadian dollars when used by Alberta producers. Futures prices and the basis can be increased or decreased in magnitude depending on the direction of change in value of the Canada/U.S. exchange rate. Novak and Unterschultz (1996) found that exchange rate risk was negligible when hedging finished cattle. This study does not attempt to measure exchange rate risk but this risk implicitly resides in the pricing of cross-currency options used in developing some of the market-based derivative contracts.

4.2.1.5 Input Price Risk

Although this study focuses on managing output price risk, changes in input prices are a source of risk to a producer. Unpredicted changes in interest rates, feed costs or other inputs can cause profits to vary. Futures contracts for many of the main feed inputs such as barley and wheat are traded on the Winnipeg Commodity Exchange and can be used to manage input price risk. This study does not include hedging inputs in its analysis but several marketing strategies were developed that forward purchased all inputs.

4.2.1.6 Hedging Strategies

For the purpose of this study, routinely hedging hogs involved hedging every pen of hogs over their entire life span. Hogs born in the same week were hedged with a futures contract at birth and the hedge was not lifted until they were sold. Routine hedging allows for the price of the commodity to be somewhat predetermined, subject to the change in the basis over the period of the hedge. The disadvantage of routine hedging is that losses are locked in (excluding change in basis) on hedges that are placed when the futures market price forecasts a loss. In other words it does not involve hedging with "a view to the market".

Selective hedging is a marketing strategy that can be used to reduce price risk and potentially increase returns to the operation. The purpose of selective hedging is to place a hedge only when the futures market offers a satisfactory projected profit. This potentially locks in a higher price over the long run than routine hedging. Variations of selective hedges may also use technical indicators to time the futures market, so that a hedge is not placed on an upward trending market. Ensuring that a target profit exists when a hedge is placed results in the producer avoiding locking in a loss on the hedge. The disadvantage of selectively hedging output is that if the target profit never exists over the production period, production is left exposed to the cash market.

Many different selective hedging strategies exist, therefore only the ones used in this study will be demonstrated. Further information on selective hedging can be found in Purcell (1991).

4.2.1.7 Margins or Performance Bonds

An initial margin requirement or performance bond is required before a broker will accept a request to purchase or sell a futures contract for an investor. Margin requirements ensure that the investor has sufficient funds to cover any potential losses from adverse price moves in the futures market. Initial margin requirements are typically five percent of the value of the contract. For example a futures contract to sell 40,000 pounds of live hogs at sixty cents per pound live weight would require an initial margin of approximately 1,200 dollars, depending on the brokerage firm.

A minimum margin or maintenance level is required if losses do occur in the investors futures market portfolio. Typical maintenance levels are two thirds of the initial margin requirement. If the investor's margin account falls below the minimum level, margin calls are issued and the investor is required to post additional money to bring the margin account back to its initial margin level.

Margin calls can be a significant barrier to producers hedging with futures contracts. If several contracts are held to hedge a cash commodity and futures prices rise, margin calls can be significant. The investor's account is closed if a margin call is not met, resulting in inadequate price risk protection.

4.2.1.8 Futures Market Pricing Efficiency

When considering the use of futures contracts or other derivatives based on futures contracts as risk management tools, it is necessary that the role of futures markets as cash price predictors be understood.

A market is said to be semi-efficient if "information is widely and cheaply available to investors and that all relevant and ascertainable information is already reflected in security prices" (Brealey et al. 1992, 314). In an efficient market, changes in the price of the asset will be solely caused by the random arrival of new information.

Even if a futures market is efficient, the futures price can be biased downward or upward. If the futures market consistently underestimates the future cash price, the futures market is biased downward or experiences normal backwardation. J.M Keynes (1930) suggested that a relatively large ratio of hedgers to speculators creates a downward biased futures market. In such a case the relatively small number of speculators demand a risk premium in order to take on a long position. If live hog futures contracts are downward biased, a producer hedging hogs with the live hogs futures contract would continually pay a risk premium to do so, and returns from hedging would be smaller than with an unbiased market (Hayenga et al. 1984).

Much research has been done investigating the efficiency of futures markets. Hayenga et al. (1984) found that from the years 1974 to 1981 deferred live hog futures contracts did exhibit risk premiums, but that risk premiums diminished one to three months to maturity. More recent research by Gore and Leuthold (1993) determined that risk premiums did not exist in individual live hog futures contracts from 1981 to 1991, but that significant risk premiums one month to maturity did exist when the contract months were aggregated, and that distant hog futures prices were not reliable predictors of future hog prices.

Koontz et al. (1992) concluded that live hog futures prices are formed rationally. They found that distant futures contracts traded at approximately average cost of feeding levels but after feeding commitments are made, market prices adjust to new expectations based on incoming market condition information. The authors stated that livestock futures markets forecasted poorly in distant contract months, but improved in predictive accuracy as the contracts approach maturity.

Relevant literature provides contradictory results regarding the efficiency of the live hog futures contract. Futures market efficiency is not directly identified or measured in this study although any risk premia in the live hog futures contract will appear indirectly through routine hedging results.

4.2.1.9 Technical Analysis

Technical analysis involves analyzing the patterns or trends in the futures price of the commodity and can be used to assist in the timing of a selective hedge. One common method of analyzing price movements in futures markets is the use of moving averages.

Moving averages are price averages calculated over some specific length of time. As the price level changes through time, a moving average will also change in the same direction. The magnitude of the change in the moving average is dependent on the length of the moving average.

Moving averages of different lengths can be combined to provide buy or sell signals to the investor. If two moving averages are used together, the shorter moving average will provide the strongest response to a market move. If the direction of the price change continues, the longer moving average will then reinforce the trend signal from the shorter moving average by also moving in the direction of the price change. A buy or sell signal is initiated when the shorter moving average crosses the longer moving average, depending on the direction of the price change.

Purcell (1991) suggested that a seven and ten day moving average combination provided accurate market trend signals. This study used a ten and fifteen day moving average combination to provide assistance in timing selective hedges. Early simulations in this study revealed that a ten and fifteen day moving average combination slightly outperformed a seven and ten day moving average combination.

4.2.2 Option Contracts

Option contracts are market traded instruments which give the holder the right but not the obligation to buy or sell a futures contract for a specific price. An option to sell a futures contract is a put option and an option to buy a futures contract is a call option.

Live hog options are purchased or sold through futures market exchanges according to the delivery month of the futures contract underlying the option and the strike price of the option. A strike price is the price at which the purchaser of the option has the right to purchase or sell a futures contract. An in-the-money option has a positive intrinsic value, immediately exercising the option would yield a positive cash flow. An out-of-the-money option has a negative intrinsic value, immediately exercising the option would yield a negative cash flow. An at-the-money option has a zero intrinsic value. If an investor possesses an option and exercises it, a position in the futures market equal to the strike price of the option is initiated. The investor must then meet all margin requirements associated with holding a futures contract.

Two general types of option contracts exist. European options are options that cannot be exercised prior to maturity of the option contract, while American options can be exercised prior to maturity of the option contract. If an option has been exercised, the investor may wish to close out the futures position by making an offsetting trade. The price at which the investor's position is closed out is the price at which that futures contract is trading upon liquidation. The investor then realizes any gains or losses from such a transaction.

An option should not be exercised unless the futures market is trading at a price that is favorable to the type and strike price of the option. If the futures market does not trade at a price below a put option's strike price, the option can be allowed to expire. When an option is allowed to expire, no other transaction costs other than the cost of purchasing the option are incurred.

Options are assets that have value, therefore the holder of an option also has the alternative of selling the option before it expires. The investor's net position is the difference between the selling and purchasing price of the option.

Purchasing an option can be directly compared to purchasing insurance. A premium is paid for the insurance but because the option does not obligate the investor to a futures market position, no performance bond is required unless the option is exercised. The only investments required to hold an option are brokerage fees and the option's premium.

Black (1976) developed a model to price European options on futures contracts. To derive this model, Black (1976) assumed that futures prices demonstrate lognormality, which is the distributional assumption of stock prices in the Black-Scholes stock option pricing model. This study assumes that all prices are lognormally distributed, and does not test for lognormality of prices. The assumption that stock prices are lognormally distributed is standard in financial theory (Hull 1993). The Black option pricing model has been criticized, however, for mispricing options that have strike prices very in or out of the money. If the tails of the true price distribution are fatter than the tails of the lognormal distribution, the option will be underpriced when using Black's model. Options will be overpriced if the tails of the true price distribution are thinner than the tails of the lognormal distribution (Hull 1995).

This study uses a modified version of the Wei (1994) European cross-currency option pricing model to develop window contracts. Modification of the Black model is necessary because options used in this study are cross-currency options. "Forward contracts and options on foreign assets are cross-currency instruments whose value depends on both foreign asset prices and the exchange rate." (Wei 1994, 1). The modified option pricing model takes the form (Wei 1994, 16):

$$Call_i = e^{-r_i(T_i - t_i)}\left[\frac{HF_t}{X_t} N(d1) - \frac{K_i}{X_{i,0}} N(d2)\right] \qquad \text{(Equation 14)}$$

and

$$Put_i = e^{-r_i(T_i - t_i)}\left[\frac{K_i}{X_{i,0}} N(-d2) - \frac{HF_t}{X_t} N(-d1)\right] \qquad \text{(Equation 15)}$$

where:

$$d1 = \frac{\ln\left[\dfrac{\left(\dfrac{HF_t}{X_t}\right)}{\left(\dfrac{K_i}{X_{i,0}}\right)}\right] + {\sigma_{i,HF,X}}^2 (T_i - t_i)/2}{\sigma_{i,HF,X}\sqrt{T_i - t_i}} \qquad \text{(Equation 16)}$$

$$d2 = d1 - \sigma_{i,HF,X}\sqrt{T_i - t_i}$$

where: $Call_i$ = call option price on for hog pen i

Put_i = put option price for hog pen i

$N(d(x))$ = normal cumulative distribution function

HF_t = current hog futures market price on day t in U.S. dollars

K_i = strike price of option in U.S. dollars (fixed over term of option)

X_t = current exchange rate in U.S. dollars to buy 1 Canadian dollar

$X_{i,0}$ = delivery exchange rate in U.S. dollars to buy 1 Canadian dollar (pre-specified and fixed over term of option)

$T_i - t_i$ = time to expiration of option (T=date of expiration, t=date of calculation)

$\sigma_{i,HF,X} = \sqrt{\sigma^2_{i,HF} + \sigma^2_{i,X} - 2\rho_i \sigma_{i,HF} \sigma_{i,X}}$ = standard deviation of returns on Canadianized futures market

ρ_i = correlation coefficient between returns on futures market and spot exchange rate (equation 18)

An explanation of the notation is needed to completely understand the aforementioned formulae. The letter i represents a single pen of hogs farrowed and sold at the same time. Therefore, the option prices reflect the price of a cross-currency call or put at a particular time for a particular pen of hogs. These option prices can be recalculated at any time period, represented by the letter t, up to expiration of the contract. This allows one to calculate a gain or loss of the option's asset values. The volatility of the option, strike price of the option and exchange rate used to Canadianize the strike price of the option are fixed in this study, therefore the subscript t is not associated with these variables. All other variables change through time up to expiration of the option. An explanation of how the volatility of the Canadianized futures price was derived follows.

4.2.2.1 Volatility

A modified version of Wei's (1994) option pricing model was used as part of the methodology of creating an Alberta-based window contract from the CME live hog futures market. The model requires a volatility estimate as one of its parameters. There are two ways to calculate futures market volatility when pricing a call or put option. One can either estimate the volatility of the futures market through historical data of futures prices or calculate the implied volatility from options being traded on the exchange at the time of establishment of the window contract (Das 1994).

Calculating the implied volatility involves finding the volatility parameter implied in actual historical option prices. Iterative techniques must be used to find the volatility parameter because one can not directly solve for volatility in the Black (1976) option pricing model and the modified version of Black's model (Wei 1994). This iteration can be done by entering all parameters into the model as they occurred at the time the option was trading, and subsequently substituting different volatility parameters until the option price from the model equals the actual market option price.

According to Das (1994), there are detriments to both methods of finding market volatility. The major difficulties with estimating futures market volatility are:

1. Estimation assumes volatility is constant over the length of the option (although so do the Black model and modified version of the Black model)
2. Specifying a correct number of observations when estimating
3. A large number of methods exist in which to estimate volatility (closing price to closing price, open to open, open to close, etc.)

Gordon (1985) found that volatility changed with time in commodity futures prices. Das (1994, 289) also stated that "stationarity of the volatility estimate is neither logical nor supported by empirical evidence. Volatilities for a variety of assets demonstrate significant changes over time."

According to Das (1994), advocates of using long sample periods (eg., five years) to estimate volatility assume that in the long run volatility is either constant or maintains an average level. Those using shorter sample sizes (one to three months) to estimate volatility assume that volatility changes over the long term but short term volatility does provide a good indication of current volatility.

The use of different types of prices (close to close etc.) also may lead to different estimates of volatility. It is often up to the type of information desired by one calculating the volatility (intra-day speculator versus hedger) as to which prices are used. Close to close prices are the most common data used to calculate volatility (Das 1994).

Problems also arise when implicitly calculating volatility from option prices. Although these prices demonstrate the perceived market volatility by traders, it is often the case that options of different strike prices yield different implicit volatilities. Different methods such as weighting of volatilities of options with different strike prices or using the closest to at-the-money option to calculate implicit volatility can be used.

Live hog options were not traded on the CME until the latter part of the 1980's, limiting the time period left to simulate if implicit volatilities were calculated. As a result, historical close to close futures prices were used to estimate volatilities. Details regarding the methodology used to calculate a volatility parameter for the modified option pricing model are presented in the following three sections.

1. Volatility Parameter in the Modified Option Pricing Model

Because the modified version of the Wei (1994) option pricing model converts a U.S. futures price with the Canada/U.S. exchange rate (defining the exchange rate as U.S. dollars to buy one Canadian dollar), the volatility parameter must be modified. The volatility parameter was calculated as:

$$\sigma_{i,HF,X} = \sqrt{\sigma_{i,HF}^2 + \sigma_{i,X}^2 - 2\rho_i \sigma_{i,HF} \sigma_{i,X}} \qquad \text{(Equation 17)}$$

where: $\sigma_{i,HF,X}$ = volatility parameter used in modified option pricing model
$\sigma_{i,HF}$ = standard deviation of returns on futures market
$\sigma_{i,X}$ = standard deviation of returns on spot exchange rate (defined as U.S. dollars to buy 1 Canadian dollar)
ρ_i = correlation coefficient between returns on futures market and spot exchange rate

and

$$\rho_i = \frac{\operatorname{cov}_i(u_{i,HF}, u_{i,X})}{\sigma_{i,HF}\sigma_{i,X}} \qquad \text{(Equation 18)}$$

where: cov_i = covariance of returns on futures market and spot exchange rate
$u_{i,HF}$ = percent return on futures market (defined below)
$u_{i,X}$ = percent return on spot exchange rate (defined below)

and

$$\operatorname{cov}_i(u_{i,HF}, u_{i,X}) = \frac{\sum_{j=1}^{57}(u_{i:t-j,HF} - \overline{u_{i:t-j,HF}})(u_{i:t-j,X} - \overline{u_{i:t-j,X}})}{n-1} \qquad \text{(Equation 19)}$$

where: $\overline{u_{i,t-j}}$ = mean of percent returns on market as calculated below
(the reason why j equals 57 is presented in the following section)

Percent returns on the futures and spot exchange rate markets are as follows:

$$u_{i,HF} = \ln\left(\frac{HF_t}{HF_{t-1}}\right) \qquad \text{(Equation 20)}$$

where: HF_t = hog futures price in U.S. dollars
$u_{i,HF}$ = percent return from holding live hog futures contract .

$$u_{i,X} = u_{i,CF} = \ln\left(\frac{CF_t}{CF_{t-1}}\right) \qquad \text{(Equation 21)}$$

where: CF_t = Canadian dollar futures price on day t in U.S. dollars to buy 1 Canadian dollar
$u_{i,CF}$ = percent returns from holding currency futures (used as substitute for $u_{i,X}$ in calculating correlation coefficient and covariance of returns in total volatility estimate, as explained in following section)

2. Canadian Dollar Futures Volatility

Because the hog futures prices are quoted in U.S. currency, they must be converted to Canadian dollars to apply to an Alberta window pricing scheme. Daily live hog futures price data were used in calculating the volatility parameter for the modified option pricing model. The same frequency of exchange rate data was required in some of the steps to calculate the volatility parameter, but this study used weekly exchange rate data. Therefore, daily Canada dollar futures prices were used in replacement of the spot exchange rate.

Hull (1993) suggested using data in the 90 to 180 day range when estimating volatility. Only four Canadian dollar futures contracts are traded on the CME. When hedging the Canadian dollar in conjunction with hog futures contracts, the appropriate Canada dollar futures contract is the contract expiring closest to but not prior to the expiration of the hog futures contract used to hedge the inventory. Prior to January 1 of 1987, many time periods existed where the appropriate Canada dollar futures contract did not trade more than 15 days prior to the day the price window was established. As a result, the Canada dollar futures contract expiring at the same or closest month prior to the expiration of the appropriate live hog futures contract was used in volatility estimation. This resulted in a maximum of 58 days prior price data available to be used in estimating volatility. To maintain consistency, volatilities of both live hog and Canada dollar futures prices and covariances between the live hog and Canada dollar futures prices were obtained through 58 days of historical price data.

The methodology used to calculate an estimation of the spot Canada dollar exchange rate from Canadian dollar futures prices is presented below.

Futures market arbitrage theory suggests that for futures contracts on exchange rates, the following is true:

$$CF = Xe^{(r_f - r)\tau} \qquad \text{(Equation 22)}$$

where: CF =Canada dollar futures price in U.S. dollars to buy 1 Canadian dollar
X =spot exchange rate in U.S. dollars to buy 1 Canadian dollar
r = current domestic interest rate
r_f = current foreign interest rate
τ = time to expiration in years (T-t)
μ = futures market drift rate

From this formula the variance of X can be calculated as (Hull 1993):

$$\sigma_X^2 = e^{2(r-r_f)}\sigma_{CF}^2 \qquad \text{(Equation 23)}$$

To calculate σ_X on day t (represented as $\sigma_{i,X}$), the following approach is used:

$$u_{i,X} = u_{i,CF} = \ln\left(\frac{CF_t}{CF_{t-1}}\right) \qquad \text{(Equation 24)}$$

where: CF_t = Canadian dollar futures price on day t in U.S. dollars to buy 1 Canadian dollar
$u_{i,CF}$ = percent returns from holding currency futures (used as substitute for $u_{i,X}$ in calculating correlation coefficient and covariance of returns in total volatility estimate)

$$R_{i,X} = \sqrt{\frac{\sum_{j=1}^{57}(u_{i:t-j,CF} - \overline{u_{i:t-j,CF}})^2}{n-1}} * e^{(r-r_f)\tau} \qquad \text{(Equation 25)}$$

where: $R_{i,X}$ = standard deviation of daily percent returns from holding currency futures contracts adjusted to represent percent returns from spot exchange rate, calculated over 58 days
r = current Canadian 90 day treasury bill yield
r_f = current 91 day U.S. treasury bill yield
τ = difference in years between maturities of currency futures contract expiring closest to but not prior to expiration of appropriate hog futures contract and Canada dollar futures contract used to estimate volatility

$R_{i,X}$ represents a daily volatility parameter but the Black (1976) option pricing model, and thus the modified option pricing model, requires an annualized volatility parameter (Hull 1995). The volatility can be annualized as follows:

$$\sigma_{i,X} = \frac{R_{i,X}}{\sqrt{\eta}} \qquad \text{(Equation 26)}$$

where: $\sigma_{i,X}$ = annualized standard deviation of percent returns on spot currency market
η = 1/number of trading days per year

3. Hog Futures Volatility

The other parameter that needs to be estimated in calculating the volatility parameter in the modified option pricing model is the hog futures market volatility, $\sigma_{i,HF}$. This was estimated as follows:

$$u_{i,HF} = \ln\left(\frac{HF_t}{HF_{t-1}}\right) \qquad \text{(Equation 27)}$$

where: $u_{i,HF}$ = percent return from holding live hog futures contract
HF_t = hog futures price, in U.S. dollars, on day t

and the daily standard deviation of percent returns from holding futures contracts is:

$$R_{i,HF} = \sqrt{\frac{\sum_{j=1}^{57}(u_{i:t-j,HF} - \overline{u_{i:t-j,HF}})^2}{n-1}} \qquad \text{(Equation 28)}$$

where: $R_{i,HF}$ = standard deviation of daily percent returns from holding hog futures contracts, calculated over 58 days

The annualized live hog futures market volatility can subsequently be calculated as:

$$\sigma_{i,HF} = \frac{R_{i,HF}}{\sqrt{\eta}} \qquad \text{(Equation 29)}$$

where: $\sigma_{i,HF}$ = annualized standard deviation of percent returns on hog futures market
η = 1/number of trading days per year

4.2.3 Forward Contracts

A forward contract is a legally binding contractual agreement between a buyer and seller to exchange a specified quantity and quality of commodity for a specified price at a particular time and location in the future. Unlike futures contracts, forward contracts are privately negotiated, not standardized, are not subject to margin calls as gains or losses accrue, have only one delivery date, are settled only at the delivery date of the contract and delivery almost always occurs (Hull 1995). The APPDC recently instituted the "Forward Price Contracting Program" to provide Alberta pork producers with the ability to forward price their hogs (APPDC 1996).

The forward price for a commodity can be calculated as the best educated estimate of the future cash price of a commodity. Because the futures market is the primary price discovery mechanism for a future price, the forward price of a commodity on a particular day is the appropriate futures price on that day minus expected basis at delivery. In order to calculate a forward price, a forecast of the basis at delivery is needed. Once a forecast of the basis at delivery is made, a forward price is calculated as:

$$\textit{Forward Price}_{t,t+1} = \textit{Futures price}_{t,t+1} - \textit{Expected Basis}_{t,\,t+1} \qquad \text{(Equation 30)}$$

where: prices and expected basis are in same currency

In theory, a properly derived forward contract will have zero value upon establishment of the contract. In practice, the accuracy of a forward contract in predicting the future local cash price is subject to the forecasting efficiency of the futures market and the basis forecasting ability of the party writing the contract.

A forward contract will not have a zero net value throughout the length of the contract. As the futures price decreases or increases between the initial and final day of the contract, the contract will take on a positive or negative net value, respectively. This is because a forward contract implicitly guarantees the producer a specific futures price, exchange rate and basis level when guaranteeing a pre-specified cash price. From the date the contract is negotiated to the date of delivery, the futures price, exchange rate and basis level will change. How these parameters change will determine who gains from the contract.

Guaranteeing the producer a price at delivery results in the writer of a forward contract taking on all of the basis risk. The writer of the contract takes on the risk that, at delivery, the basis will be wider than the guaranteed basis in the forward contract. If the basis locked into the forward price is too narrow, the provider of the contract guarantees a cash price that is too high. Correspondingly, if the locked in basis is too wide, the writer guarantees a cash price that is too low. The exchange rate and price risk can be hedged by the contract writer.

Forward contracting provides the advantage that all output price risk to the producer is eliminated. Once a delivery price is established, the producer knows exactly what price will be received for the commodity, provided the terms of the contract are exactly met. Fluctuations in the cash market, futures market and corresponding basis level will not affect the final realized price. This provides the producer with the ability to know with certainty his or her ability to meet any known fiscal responsibilities.

Production risk demands that producers ensure they are able to fill the qualitative and quantitative terms of the contract. Failure to do so can result in large price discounts or the producer having to buy the commodity on the cash market to fill the contract. Both can result in large and unpredicted losses. Because this study does not incorporate production risk into the simulated hog operation, all anticipated production is known with certainty and contracted in the routine forward contracting simulation (discussed in section 5.2.4.1).

Some of the marketing strategies examined in this study required a basis forecast, thus several basis forecasting models were developed. A complete explanation of the basis forecasting models developed and analyzed is detailed in Chapter 5 and Appendix C. The basis forecasting model used in this study, determined through the forecasting analysis in Chapter 5, was a one year rolling average of the nearby basis.

4.2.4 Window Contracts

Window contracts are a variation of forward contracts that are relatively new to the hog industry. Window contracts offered in Manitoba are short term contracts priced off of current futures market prices. U.S. window contracts are usually longer term, being three to ten years in length. These instruments were developed to provide a mechanism which partially protects from decreasing market prices but provides greater flexibility in gaining from upward market moves than forward contracts (Lawrence 1995).

A window contract establishes a price floor and ceiling for the duration of the contract. A 50/50 sharing agreement splits gains or losses equally between the producer and provider of the contract when prices are outside of the window. A no sharing agreement provides full price protection when prices are outside of the window. When market prices at delivery are within the window, the producer receives the current index 100 cash price multiplied by the premium received for hogs above or below the index price. When market prices are below the contract floor price, the producer either receives the average of the two prices in a 50/50 sharing agreement or receives the window floor with a no sharing agreement. When market prices exceed the ceiling price in the contract, the producer either receives the average of the two prices in a 50/50 sharing agreement or receives the window ceiling in a no sharing agreement . Index premiums are then multiplied to the resulting price. This results in a mechanism in which producers forego opportunities to fully realize high market prices above the ceiling price in exchange for partial or complete protection from market prices lower than the contract floor price.

The major issue in establishing window contracts is where to establish the window floor and ceiling prices. This issue is composed of two concerns:

1) Forward contracts should have zero initial value
2) The narrower the window offered on a particular day, the greater the implicit risk sharing between parties (parties involved should set floor price on some pre-established criteria)

According to option pricing theory, the value of an option represents the value of the right to buy or sell a futures contract at the option's strike price. These options account for current volatility parameters and time to expiration. Using the modified option pricing model therefore yields the value of a contingent claim on the exchange rate adjusted futures market taking into account the probability of the range of outcomes on the future price and exchange rate. A window contract can thus be fairly established as long as the value of an out-of-the-money cross-currency put option equals the value of an out-of-the-money cross-currency call option.

The contract is established by:

1. Choosing a floor price below the current exchange rate adjusted futures market price.
2. Calculating the value of a cross-currency put option with a strike price equal to the floor price.
3. Solving for the strike price of a cross-currency call option necessary to yield the value of the cross-currency put option.

The resulting strike price of the call option will yield the fair ceiling price of the window, given the prevailing parameters.

The ceiling and floor prices must be adjusted with a basis forecast to localize the window contract. This is because prior to adjusting for basis, the window represents a window contract offered in Chicago in Canadian dollars, which does not account for delivery costs. Adjusting for the basis yields a contract established around the local forecasted cash price rather than the forecasted price in Chicago. Therefore the basis forecasting ability of the party offering the contract and the methodology used to establish the price window are integral in fairly establishing a window contract. If the forecasted basis offered in the contract is too narrow, the localized window ceiling and floor prices will be too high. Conversely, if the forecasted basis offered in the contract is too wide, the localized window ceiling and floor prices will be too low.

Window contracts were valued in this study using the modified version of the Wei (1994) option pricing model. The nature of the window contract is identical to the producer purchasing a put option from the contract provider and the contract provider purchasing a call option of equal value from the producer. The number of options purchased and sold depends on the payoff scheme of the window. Assuming that the quantity of hogs in one option contract equals the quantity of hogs to be sold, a producer purchasing one put and selling one call to the contract provider agrees not to share gains or losses outside of the window. A 50/50 sharing agreement means the quantity of hogs to be sold doubles the quantity of hogs in the put option purchased and the call option sold. Because the basis is locked into the contract at the time of negotiation when localizing the window, the contract provider bears all of the basis risk. The payoffs are demonstrated below.

Figure 3. Payoff from Buying One Put and Selling One Call

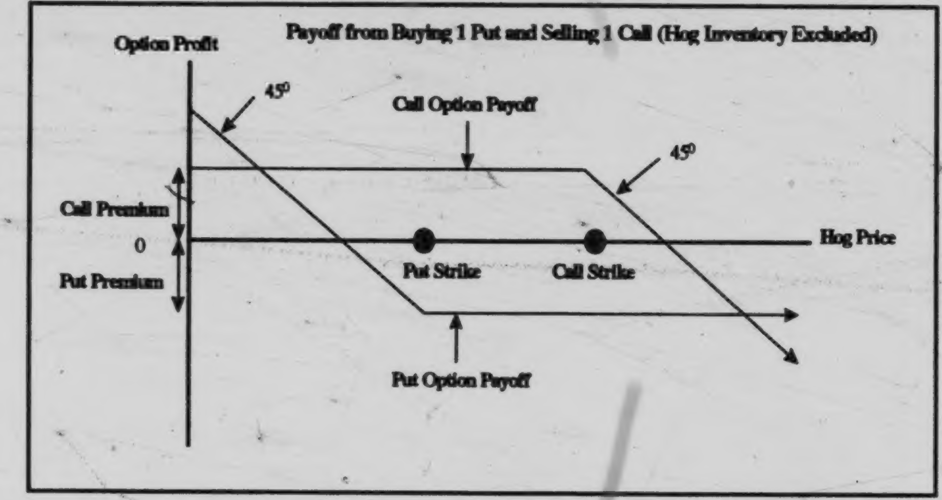

Option Profit
Payoff from Buying 1 Put and Selling 1 Call (Hog Inventory Excluded)
45°
Call Option Payoff
45°
Call Premium
0
Put Premium
Hog Price
Put Strike
Call Strike
Put Option Payoff

Figure 4. Combined Payoff from Put and Call Options

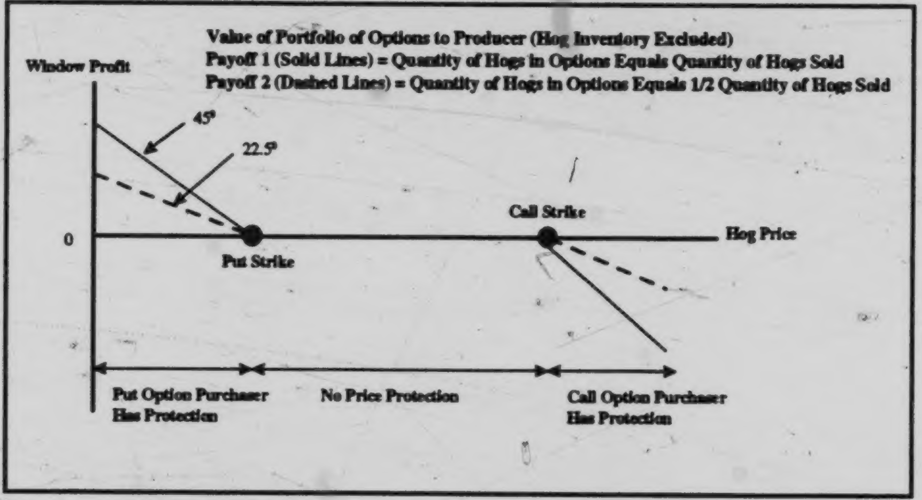

Value of Portfolio of Options to Producer (Hog Inventory Excluded)
Payoff 1 (Solid Lines) = Quantity of Hogs in Options Equals Quantity of Hogs Sold
Payoff 2 (Dashed Lines) = Quantity of Hogs in Options Equals 1/2 Quantity of Hogs Sold
Window Profit
45°
22.5°
0
Put Strike
Call Strike
Hog Price
Put Option Purchaser Has Protection
No Price Protection
Call Option Purchaser Has Protection

Figure 5 demonstrates the payoff schedule realized by a producer selling hogs on the cash market.

Figure 5. Payoff from Cash Marketing

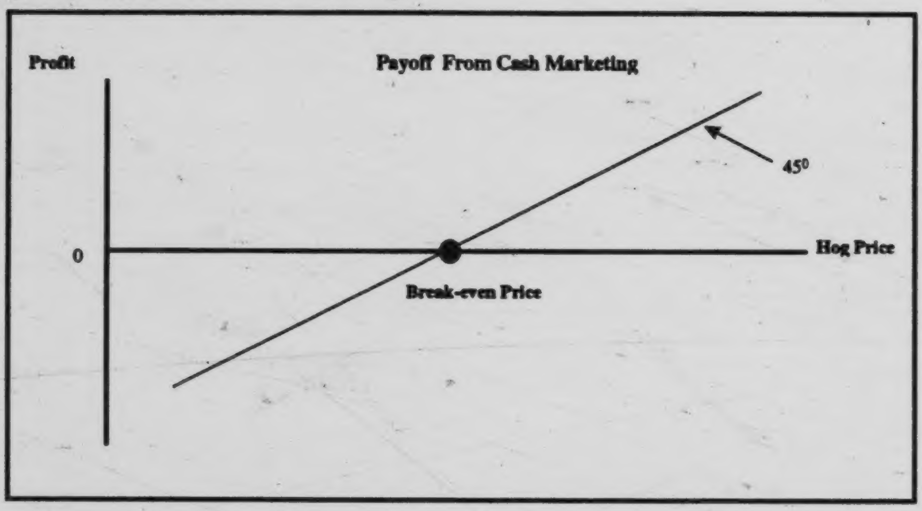

Profit
Payoff From Cash Marketing
45⁰
0
Hog Price
Break-even Price

Figure 6 demonstrates the payoff to a producer taking a window contract when the break-even price is between the put and call strike prices. This payoff is constructed by combining the payoffs of Figures 4 and 5. A break-even price located somewhere other than between the two strike prices will cause the payoff schedule to change, but the methodology in which the total payoff line was constructed remains the same.

Figure 6. Payoff to Producer Taking a Window Contract (Zero Basis Risk)

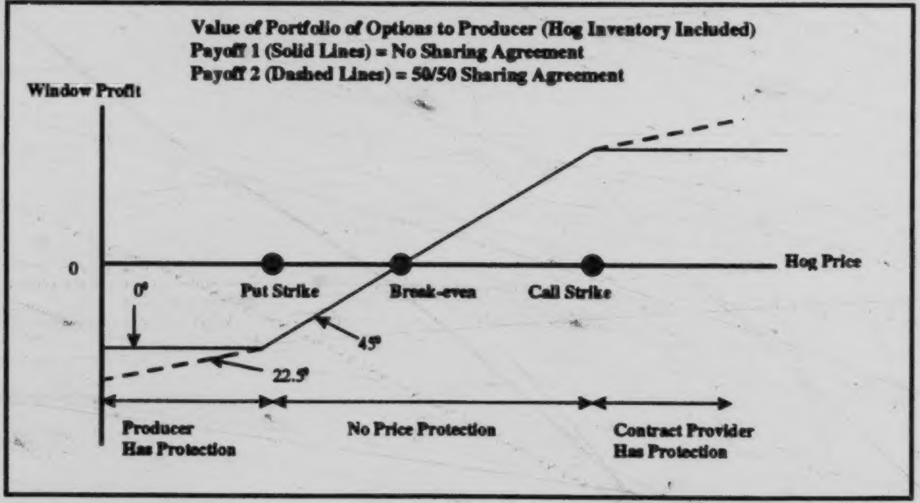

Value of Portfolio of Options to Producer (Hog Inventory Included)
Payoff 1 (Solid Lines) = No Sharing Agreement
Payoff 2 (Dashed Lines) = 50/50 Sharing Agreement
Window Profit
0
Hog Price
0°
Put Strike
Break-even
Call Strike
45°
22.5°
Producer Has Protection
No Price Protection
Contract Provider Has Protection

Figure 6 demonstrates the payoff to a producer taking a window contract. This is identical to the payoff of a fence strategy with options. The only difference is that zero basis and exchange rate risk resides in the window contract taken by the producer. Because the basis is guaranteed by the provider of the contract, the provider of the contract takes on this risk. If the basis at delivery turns out to be wider than the basis guaranteed in the contract, the contract provider set the window too high. This benefits the producer because price protection occurs at a higher price than was necessary. Figure 6 demonstrates how a producer taking a window contract receives protection when cash hog prices are below the strike price of the put option (floor price of the window) and how the contract provider receives protection when cash hog prices are above the strike price of the call option (ceiling price of the window).

4.3 Previous Research

Previous research has assessed the effectiveness of many different marketing instruments and techniques in reducing hog marketing risk. Using hedging simulation techniques for the period of January, 1976 through April, 1984, Brandt (1985) found that an ARIMA or composite-simple average price forecasting model combined with a selective hedging strategy reduced price risk and increased prices received by producers compared to cash marketing, though improvements over the mean and standard error of cash marketing were small. A hedge was placed if the current basis adjusted futures market price exceeded the forecasted cash price for that respective time period. Once a hedge was placed, it remained until the hogs were sold. The author found routine hedging increased risk and lowered mean returns compared to cash marketing.

Holt et al. (1985) simulated a farrow to finish hog operation from February, 1977 through January, 1983 to explore whether selectively placing and lifting hedges could reduce price risk and increase the mean price received by producers over routine hedging. In their study, a hedge was placed if the current basis adjusted futures market price exceeded the forecasted cash price for that time period. The producer had three opportunities to place a hedge and subsequent opportunities to lift and replace or not replace the hedge, depending on the forecasted price/futures price relationship. The authors found that combining a price forecasting model with a dynamic selective hedging program reduced price risk and enhanced the price received by the producer compared to routine hedging.

More recent research by Gore and Leuthold (1993) reinforced that some selective hedging strategies from 1981 to 1991 increased mean returns and decreased variance of returns compared to cash marketing. Again the improvements in mean and variance were relatively small. Routine hedging resulted in the lowest mean return and variance of all marketing strategies, including cash marketing. Put options were also examined as a marketing alternative for the purpose of reducing price risk. They found that regardless of the option strategy used, lower mean returns and variances resulted from using put options as price insurance compared to a similar futures market hedging strategy and cash marketing.

Kenyon and Clay (1987) researched the usefulness of cross hedging the major hog feed inputs, corn and soybeans, on their respective futures contracts in conjunction with hedging with live hog futures contracts to lock in a profit margin to the producer. They simulated a 150 sow farrow to finish hog operation from 1975 to 1980 to examine the ability of two different selective hedging strategies in reducing risk compared to the cash market. The first strategy involved hedging when a predetermined fixed profit margin was forecasted using hog, soybean and corn futures through cross hedging hogs and soybeans and corn, hogs and corn or hedging hogs only. The second strategy involved estimating the relationship between cash margins and hog production and feed prices, and hedging hogs and corn if the futures market provided a desirable level of profit margin over the forecasted cash margin attained from production estimates from the U.S. Hogs and Pigs Report combined with soybean and corn futures prices. The authors found that hedging hogs only when a particular expected profit margin occurred increased average returns and reduced the variance of returns compared to cash marketing, depending on the level of desired expected profit. Similarly, some of the strategies which involved hedging hogs and hedging corn increased average returns and reduced the variance of returns compared to cash marketing, once again depending on the expected profit margin. Hedging hogs, corn and soybeans increased the variance of returns and therefore was not risk reducing. Hedging when a profit margin 60% to 70% higher than the forecasted cash profit margin existed also reduced variability of profits and increased mean profits compared to cash marketing.

Novak et al. (1992) also used simulation techniques to examine the effectiveness of several different marketing alternatives, including and excluding the NTSP program, in reducing price risk. Strategies such as 100% hedge and hold and optimal hedging reduced risk but also reduced returns compared to cash marketing.

No research has been reported examining the effectiveness of window contracting on reducing price risk to producers. This is probably due to the fact that these contracts are relatively new and are only recently becoming popular.

4.4 Chapter Summary

This concludes the review of risk theory and risk management tools and applications discussed in Chapter 4. Chapter 4 presented methods in which risk can be measured and decision making models that provide a framework in which to evaluate the returns from alternative marketing strategies. This was followed by an explanation of some of the derivative contracts that are available to Alberta producers, and the advantages and disadvantages of using such market-based instruments.

Chapter 5 provides the methodology used in this study to examine the risk reducing effectiveness of the different marketing alternatives previously discussed, and the results from each marketing strategy.

5. Simulation Methodology and Results

This chapter first provides an explanation of the methodology used to simulate a typical farrow to finish hog operation. This is followed by an evaluation of the effect of different risk management techniques such as routine and selective hedging and routine forward contracting on the mean, standard deviation and other measures that describe the revenue distribution of the hog operation (discussed in section 5.2).

5.1 Methodology

A typical 350 sow farrow to finish hog operation was simulated in order to produce return calculations under various marketing strategies for the period of 1981 to 1995. Although this farm represented a typical farrow to finish enterprise (Perkins 1996; Shaw 1996), it was not specifically any one enterprise. The operation was hypothesized to exist in the Red Deer area, with feed grains and other inputs being purchased from that region.

Sows were assumed to produce 19.6 marketed pigs per year. The sows farrowed 2.23 times per year and produced 10 living piglets per litter. This translated to 15 farrowings per week and 150 pigs born alive per week. After death losses of 10, 1 and 1.5 percent at different stages of production, approximately 132 of the original 150 pigs were available to be sold at finish. A pen of pigs therefore comprised all pigs born in the same week and this study followed each pen of pigs from birth to finish.

The piglets were weaned at three weeks (7 kilograms), with veterinary and medical care being given at weaning. Once the pigs were weaned, they were fed in five different stages on three different rations, as detailed in Table 14, Appendix A (Gowans Feed Consulting 1996; Aherne 1996). The stage of growth reflected the weight class of the pigs.

Starter 1 pigs were fed a starter ration from 7 to 15 kilograms, which comprised four weeks of feeding. Starter 2 pigs were also fed a starter ration from 15 to 20 kilograms, which took two weeks. Grower pigs were fed a grower ration for seven weeks from 20 to 50 kilograms. Finisher 1 pigs were fed a finisher ration for three weeks from 50 to 70 kilograms. Finisher 2 pigs were also fed a finisher ration from 70 to 107 kilograms, which took six weeks. Rates of gain and feed conversions were adjusted to accurately reflect performance at each stage of growth.

A pen of pigs thus needed a total of 175 days to reach market weight from the day of birth. Accounting for weaning at three weeks of age resulted in the pigs requiring 154 days on feed to reach market weight. The hogs were assumed to dress out at 80 percent, with a 58 percent lean yield. This resulted in marketed hogs indexing at 1.07 times the Alberta Index 100 hog price.

The breeding stock was comprised of boars and breeding sows, with replacement stock being purchased rather than obtained from within the operation. These animals were assigned static feed intake requirements which did not change over the period of the study.

Annual ownership costs were calculated assuming that the farm was amortized over twenty years at ten percent. A capital requirement of 3,000 dollars per sow and zero salvage value after twenty years generated a gross value of buildings and equipment at the beginning of the study of 1,050,000 dollars. A land purchase of 60,000 dollars, also amortized over twenty years at ten percent interest, was made at the beginning of the study. The breeding stock was assumed to exist at the beginning of the study with no debt existing on the herd.

Costs were assigned to each pen of pigs for each week from farrow to finish according to prevailing input prices at the time. Labor requirements, breeding stock purchases, labor, trucking and all other costs were allocated among pens accordingly. The pigs were immediately marketed upon reaching finishing weight. A detailed explanation of the farrow to finish operation is provided in Appendix A.

5.2 Results

Section 5.2 provides a summary of the marketing alternatives simulated for the purpose of managing risk.

Returns to the operation were calculated in the following manner (a more detailed explanation of costs and revenues can be found in Appendix A):

$$TotCost_{t+j} = FixCost_{t+j} + VarCost_{t+j} \qquad \text{(Equation 31)}$$

$$Net\,\mathrm{Re}\,v_{t+j} = Tot\,\mathrm{Re}\,v_{t+j} - Tot\cos t_{t+j} \qquad \text{(Equation 32)}$$

$$\mathrm{Re}\,alNet\,\mathrm{Re}\,v_{t+j} = Net\,\mathrm{Re}\,v_{t+j} * \frac{CPI_{Dec1995}}{CPI_{t+j}} \qquad \text{(Equation 33)}$$

where: $TotCost_{t+j}$ = nominal total cost per hog at time of sale
$FixCost_{t+j}$ = nominal total fixed costs incurred per hog at time of sale
$VarCost_{t+j}$ = nominal total variable costs incurred per hog at time of sale
$Net\,\mathrm{Re}\,v_{t+j}$ = nominal net revenue per hog at time of sale
$Tot\,\mathrm{Re}\,v_{t+j}$ = nominal total revenue per hog at time of sale
$\mathrm{Re}\,alNet\,\mathrm{Re}\,v_{t+j}$ = real net revenue per hog at time of sale in 1995 dollars
CPI = consumer price index
t = week of birth
j = weeks from birth to sale

Annualized real rates of returns were calculated as follows:

$$Ann\,\mathrm{Re}\,t_{t+j} = \left[\left(\frac{Net\,\mathrm{Re}\,v_{t+j}}{TotCost_{t+j}} + 1\right)^{\frac{365}{175}} - 1\right] * 100 \qquad \text{(Equation 34)}$$

The annualized real rate of return, expressed as a percentage, represents the real rate of return on investment from producing pigs. The mean and standard deviation of percent returns were used in the E-V and CML analysis presented in Chapter 8.

Several different criteria were used to evaluate the results of each marketing strategy analyzed. All real figures were presented in 1995 dollars. The criteria used to evaluate the results of simulated marketing strategies were:

1. Mean of real net revenues per head - represents the statistical average of return series as a measure of profitability, used as part of E-V analysis (Equation 8)
2. Standard deviation of real net revenues per head - represents the standard deviation of return series as a measure of return variability, used as part of E-V analysis (Equation 10)
3. Maximum real net revenue per head - represents the largest profit per head of return series
4. Minimum real net revenue per head - represents the largest loss per head of return series, used as part of safety-first evaluation
5. Frequency of real net revenues less than 20 dollars per head - represents the number of times a loss greater than 20 dollars per head was realized in return series, used as part of safety-first evaluation
6. Frequency of real net revenues less than 40 dollars per head - represents the number of times a loss greater than 40 dollars per head was realized in return series, used as part of safety-first evaluation
7. Percentage of losing pens - represents the percentage of times real net revenues were less than zero (out of 758 marketings)
8. Also used to examine some marketing strategies were figures describing the percentage of times that a particular hedge or window contract was taken (out of 758 marketings)

5.2.1 Cash Marketing

The cash marketing simulation reproduced the returns that would have been realized from the simulated hog farm marketing hogs at the Alberta cash price.

The following figure provides an illustration of the costs and revenues incurred by the simulated hog farm when operating from 1981 to 1995. Each pen of hogs was sold 25 weeks after farrowing on the Alberta cash market, and costs and revenues were calculated as in Appendix A.

Figure 7. Real Costs and Revenues per Head - Cash Marketing (1995 Dollars)

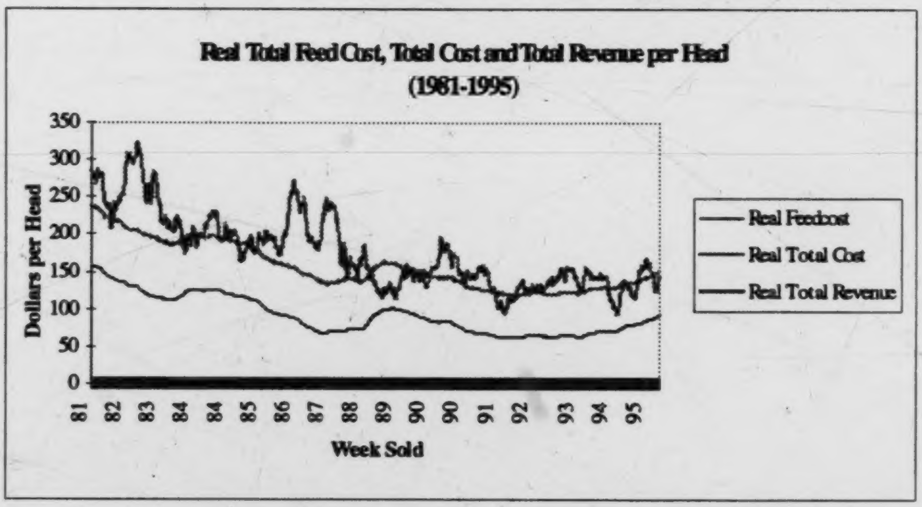
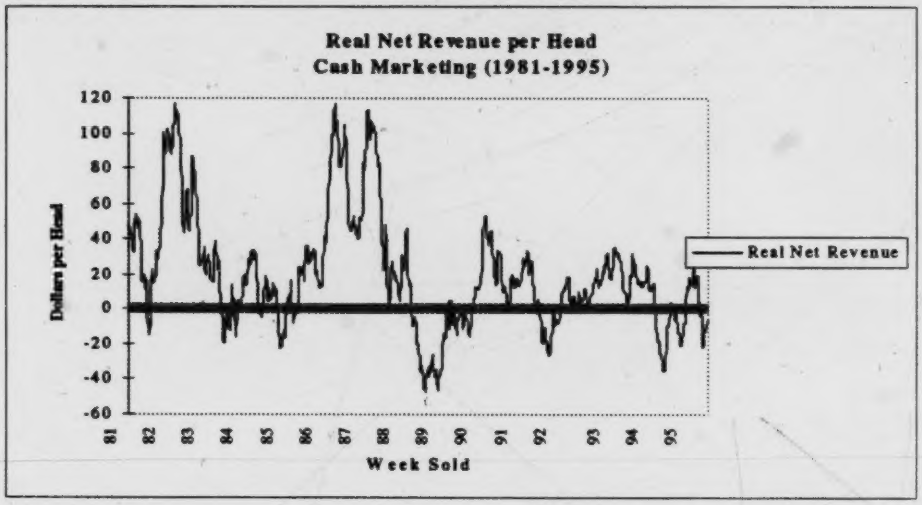


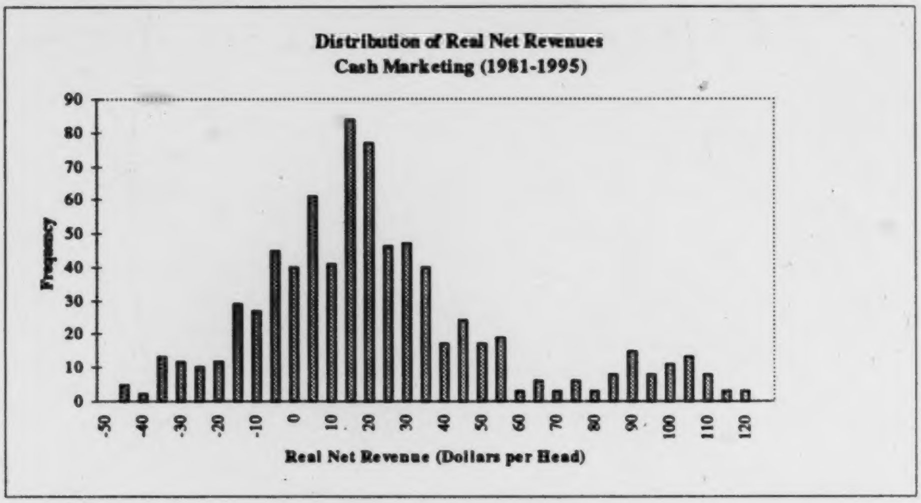
Figure 8 provides a graphical representation of the cash marketing real net revenues from 1981 to 1995 . Of interest are return figures in late 1988, early 1989, late 1991, early 1992, late 1994 and early 1995 in which large losses occurred. These losses all occurred between the months of October and May, and were focused most heavily in the winter months. The losses of 1988, 1989 and 1994, 1995 are probably due to a combination of high feed and low hog prices, while the losses seen in 1991 and 1992 appear to be due to a low hog price (Figures 10 and 11). The largest real net revenue occurred in 1986 and was 116.86 dollars per head, while the largest loss of 46.98 dollars per head occurred in 1988. This results in a range of real net returns of 163.84 dollars per head.

Figure 8. Real Net Revenue per Head - Cash Marketing (1995 Dollars)



The distribution of real net revenues to the operation (Figure 9) indicates the frequency of observing net returns of different magnitudes over the period of the study. The large width of this distribution shows that returns were very spread out and although several large net returns were realized, several large losses also occurred (Table 2).

Figure 9. Distribution of Real Net Revenues - Cash Marketing



It is evident from Figures 8 and 9 that the real net revenues from cash marketing were extremely variable over the time period analyzed. In many cases, large losses or large gains can be attributed to the volatile nature of hog and feed prices. Figure 10 illustrates the variability in the prices of feed grains, a major input cost, over the time period of the study. Feed grains used in the operation can account for over 60% of costs to the farrow finish enterprise, therefore high grain prices do adversely affect farm profitability. During late 1988, early 1989 and late 1994, early1995, there existed a situation where both barley and wheat prices sharply increased in conjunction with a dramatic decrease in hog prices. This accounts for the large losses evident in these time periods. During late 1991 and early 1992, feed prices remained at lower levels but hog prices again were very low, explaining the losses suffered during these years. Adjusting these losses for inflation had the impact of magnifying the losses in real terms.

Figure 10. Variability in Feed Grain Prices

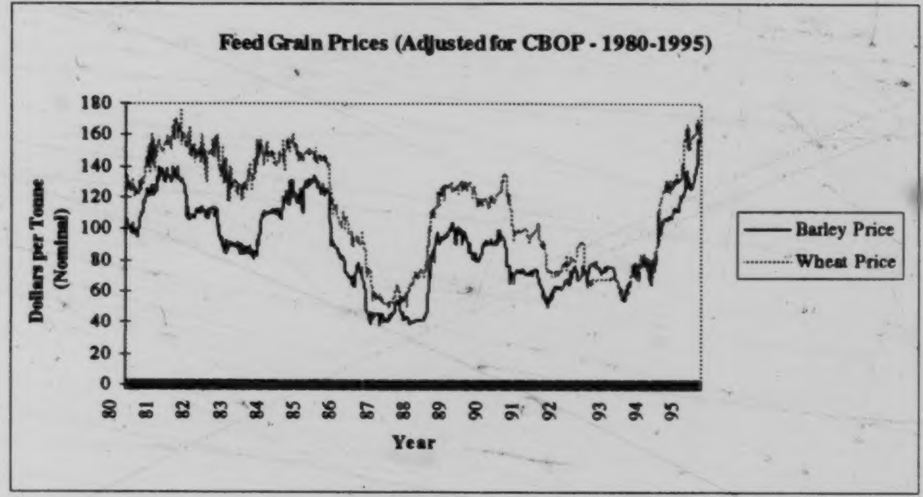
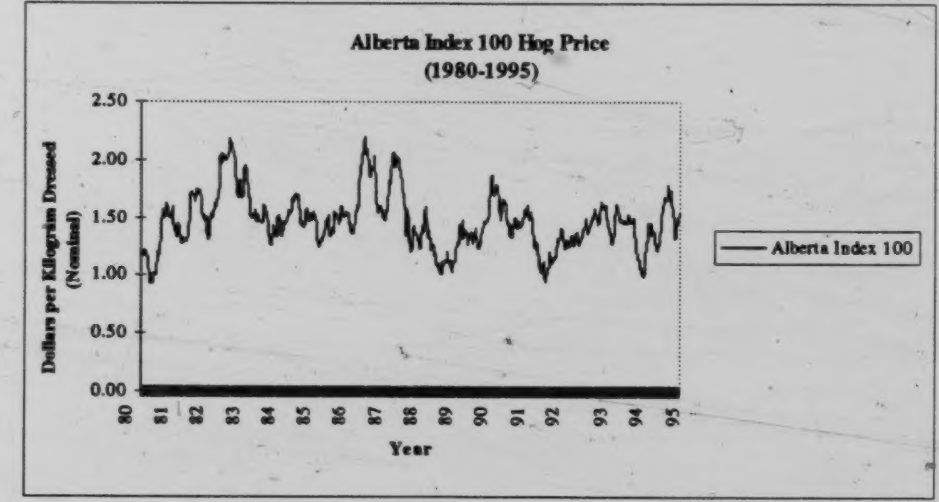
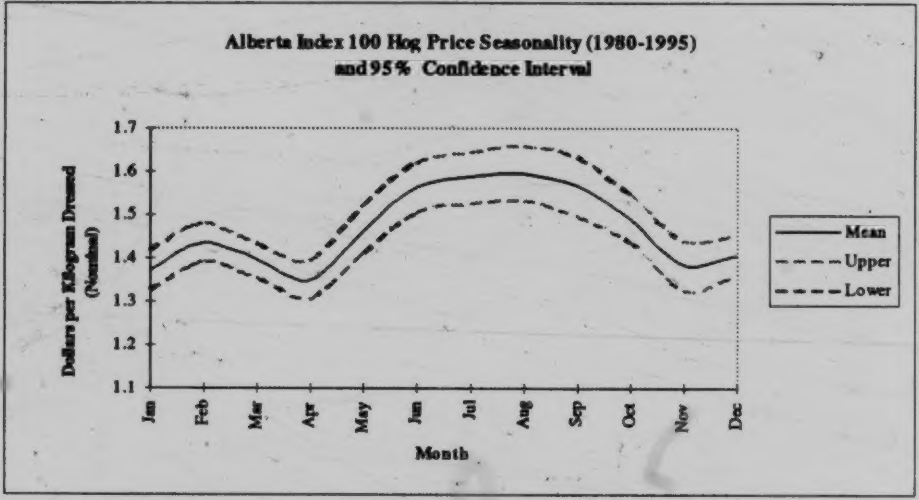


Figure 11. Alberta Index 100 Hog Price



Another factor potentially influencing the variability of returns when selling hogs on the cash market is hog price seasonality. Figure 12 demonstrates the seasonal nature of hog prices in Alberta. Hog prices are usually higher in the months of June, July, August, September and February and lower in the months of November, December January and March. The 95% confidence interval illustrates the range in which one would expect the Index 100 hog price to be 95% of the time.

Figure 12. Seasonality in Nominal Alberta Finished Hog Prices



The real net revenues from the cash marketing strategy demonstrate the effect that hog price seasonality has on returns. All periods of large losses occurred during or near the winter months when hog prices are usually lower.

Because the selective hedging simulations discussed later in the section begin in 1981, the statistics reported for both the cash and routine hedging strategies represent the time period 1981 to 1995. The operation sold 758 pens of hogs during this time period.

The mean and standard deviation of real net revenue per head provide insight into the profitability and risk of operating a farrow to finish farm in the Red Deer region from 1981 to 1995. The results of the cash simulation show that hog production was profitable in the long run (positive mean real net revenue) but exhibited a large standard deviation of real net revenues (Table 2). The mean and standard deviation of nominal net revenues to the operation were 14.54 and 24.70 dollars per head, respectively. The mean and standard deviation of real net revenues were 19.72 and 32.94 dollars per head, respectively. Real losses (1995 dollars) greater than 20 dollars per head were incurred on 54 pens of hogs, while real losses greater than 40 dollars per head occurred selling 7 pens of hogs. The operation incurred real losses on

25.7 percent of the pens sold. These figures will be used as benchmarks for comparison with other marketing strategies presented in subsequent sections.

Table 2. Cash Marketing Real Net Revenues in 1995 Dollars - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens
Cash Marketing	19.72	32.94	46.98	116.86	54	7	25.7

5.2.2 Routine Hedging

The results from cash marketing hogs from 1981 to 1995 indicate that although hog production was profitable, a high frequency of large losses occurred. Also, the standard deviation of real net revenues was 32.94 dollars per head, which may be unacceptable to some producers. Many producers may be interested in strategies that can reduce revenue variability and the frequency of large losses. As a result several different marketing strategies, which incorporate market derivatives, were simulated and analyzed in their risk reducing properties. The next marketing strategy evaluated was routinely hedging hogs with the CME live hogs futures contracts.

Routinely hedging production involved selling a CME live hogs futures contract each week when a pen of hogs were farrowed and holding that contract until the hogs were sold, at which time the futures position was liquidated. In this study it was assumed that the quantity in one CME live hogs contract exactly matched the total quantity of hogs sold per week. Hedging profits were adjusted to Canadian dollars using the spot exchange rate at the time the hedge was lifted. It was assumed that no initial margins, margin calls or brokerage fees were incurred by the hedger. All 758 pens of hogs were hedged in the routine hedging strategy. Revenues with a hedging strategy were calculated using the following equation:

$$Net\,\mathrm{Re}\,v_{t+j} = \left(Tot\,\mathrm{Re}\,v_{t+j} - Tot\cos t_{t+j}\right) + \left(\left(HF_{t,t+j} - HF_{t+j}\right) / \,Can\$_{t+j}\right) * Outwt * 0.79 * \left(\frac{2.204lbs}{Kg}\right)$$

(Equation 35)

where: $Totrev_{t+j}$ = nominal total revenue per hog from selling hog on cash market

$Tot\cos t_{t+j}$ = nominal total cost per hog at time of sale

$HF_{t,t+j}$ = futures price at week t (farrowing) of hog futures contract expiring closest but not prior to week t+j (finish) in U.S. dollars per pound liveweight

HF_{t+j} = futures price at week t+j (finish) in U.S. dollars per pound liveweight

$Can\$$ = spot exchange rate (U.S. dollars to buy 1 Canadian dollar)

$Outwt$ = hog finishing weight in kilograms liveweight

0.79 = conversion from live to dressed weight

$$\mathrm{Re}\,alNet\,\mathrm{Re}\,v_{t+j} = Net\,\mathrm{Re}\,v_{t+j} * \frac{CPI_{Dec1995}}{CPI_{t+j}} \qquad \text{(Equation 36)}$$

where: $\mathrm{Re}\,alNet\,\mathrm{Re}\,v_{t,t+j}$ = net revenue in 1995 dollars

5.2.2.1 Routine Hedging Results

The returns from routinely hedging production are illustrated in Figure 13 and the results from routine hedging are compared to cash marketing returns in Table 3.

Figure 13. Real Net Revenue per Head - Routine Hedging (1995 Dollars)

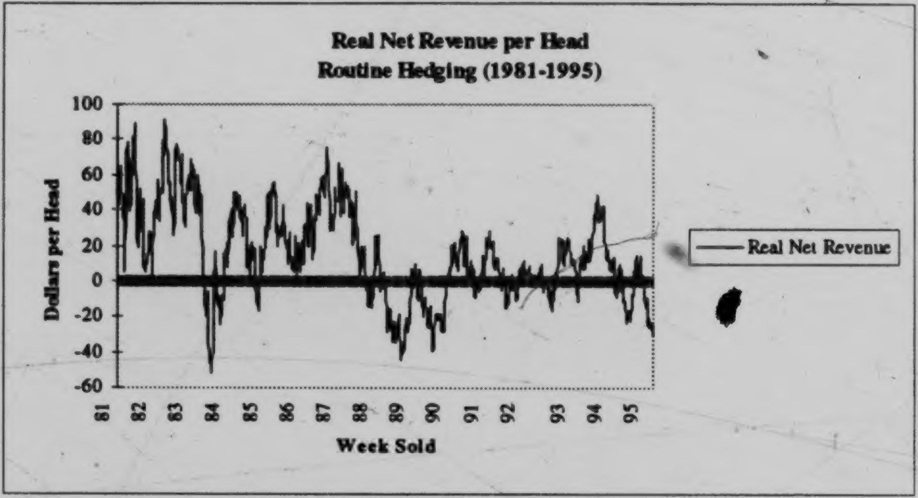
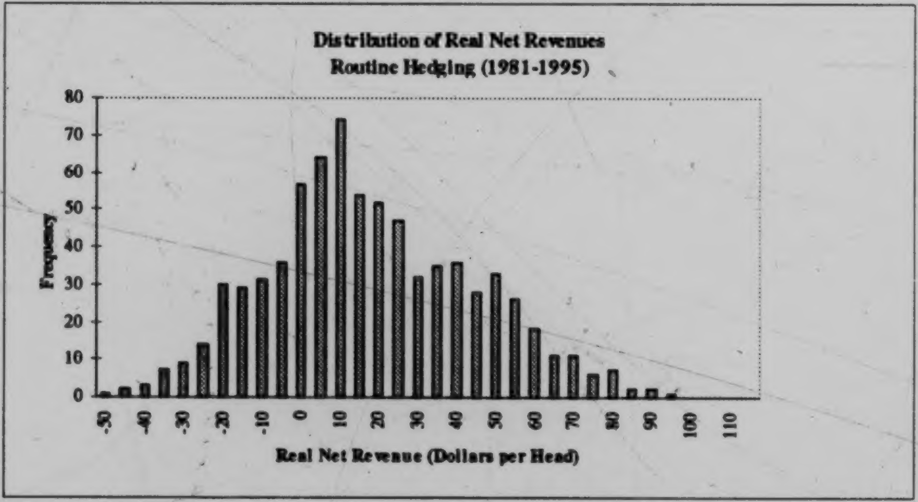


Figure 14. Distribution of Real Net Revenues - Routine Hedging



The routine hedging revenue distribution is narrower in dispersion than the cash marketing return distribution, indicating variability of returns is reduced when routinely hedging production. The narrowing of the distribution, however, was due to fewer large profits rather than fewer large losses compared to cash marketing, which is not the desired result of any risk management strategy.

The results indicate that although the standard deviation of returns was lowered with routine hedging, so was the mean of returns (Table 3). The maximum loss, occurring in January of 1984, actually increased with routine hedging due to locking in a loss and a widening of the basis on that hedge (Figure 15). The maximum profit decreased with the routine hedging strategy, indicating that hedging production results in the producer foregoing opportunities to gain from upward moves in the cash market. The high frequency of real losses greater than 20 and 40 dollars per head indicate that the routine hedging strategy did not truncate the lower end of the return distribution, which is desired with a risk management strategy. In fact, routinely hedging production instead truncated the upper end of the distribution, with many fewer pens resulting in profits over 90 dollars per head compared to cash marketing (Figures 9 and 10). This was due to the producer locking in a loss on several pens of hogs with hedging and/or a widening of the basis over the period of the hedges (Figure 15). Also, a greater percentage of pens resulted in real losses with routinely hedging production.

Table 3. Comparison of Real Net Revenues - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens	% Pens Hedged
Cash Marketing	19.72	32.94	46.98	116.86	54	7	25.7	-
Routine Hedging	15.18	26.32	51.78	90.97	66	6	28.9	100

Routinely hedging production had the effect of reducing return variability, but it reduced mean returns as well. These routine hedging results are similar to those reported by Gore and Leuthold (1993). This could be due to a potential presence of normal backwardation in the live hog futures contracts. Hayenga et al. (1984) found that, from 1974 to 1981, the live hog futures contract demonstrated significant risk premiums in deferred contracts up to one to three months to maturity. Hogs were routinely hedged for approximately six months in this analysis. This may mean that the live hog futures contract exhibited a risk premium over the period of this study.

Figure 15 shows the change in the hog basis over the period of the hedge. A widening of the basis is indicated by a negative change in the basis on the vertical axis. The basis at sale time was wider than a 52 week rolling average of nearby basis used as a forecast 51% of the time (see section 5.2.3.4).

Figure 16 shows the forecasted profits at sale time, as calculated in section 5.2.3.1. The producer hedged even though the forecasted profit was negative 60% of the time (Equation 38).

Figure 15. Change in Real Basis over Hedging Period (1995 Dollars)

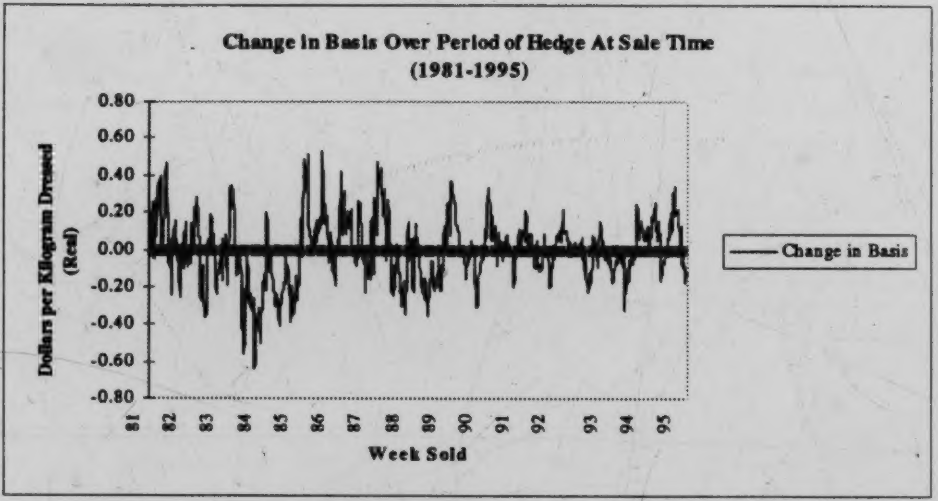
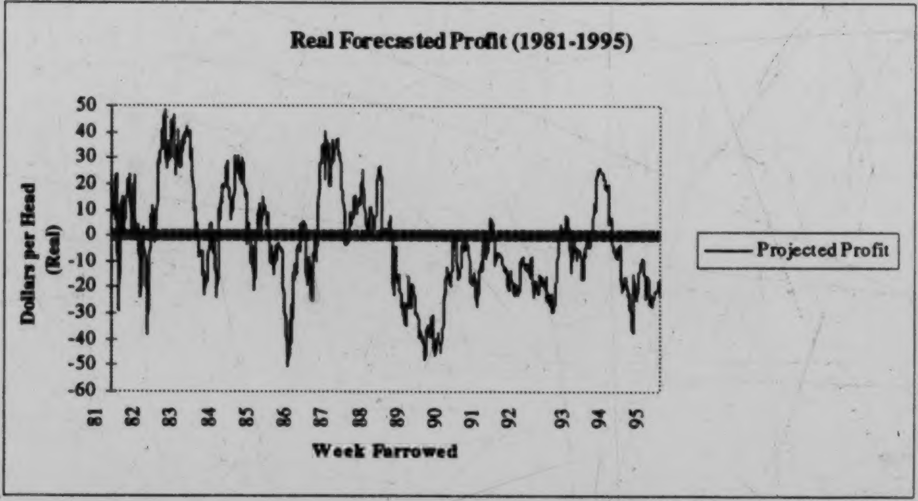
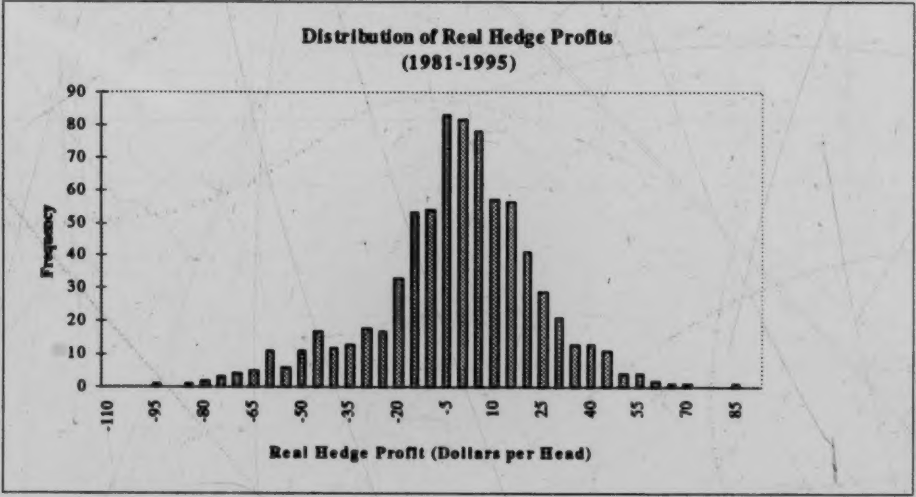


Figure 16. Real Forecasted Profit (1995 Dollars)



Although the frequency of large losses was reduced with routine hedging, they were not completely eliminated. Real net revenues from late 1983, early 1984, late 1988, early 1989 , early 1990 and early 1995 were highly negative due to a number of circumstances. Feed prices were high during most of those time periods (Figure 10) and in all cases the Alberta Index 100 price sharply moved either up or down (Figure 11). Hedging the hogs during these periods resulted in the futures market not compensating for losses on the cash market fully in cases of a dramatically downward moving cash price, or overcompensating gains on the cash market during dramatic downward moves in the cash price. This translates to basis risk affecting the realized price during some of these time periods. Also, many of the pens were hedged even though the forecasted profit was negative, locking in a loss on these pens.

Figure 17. Distribution of Routine Hedging Trade Profits (1995 Dollars)



The distribution of trade profits shows a wide range of trading profits from 1981 to 1995. Although the distribution appears somewhat normal, one cannot ignore the high frequency of large losses on the futures market on some trades. The maximum real hedge profit realized during the study was 82.36 dollars per head and the minimum real hedge profit was -96.02 dollars per head. Losses from a routine hedging program have been shown to potentially reduce overall profitability in an operation while achieving the desired reduction in variability of returns.

Although margin calls do not represent a realized loss until the hedge is offset, they can severely restrict hedging effectiveness if the producer is forced to offset the hedge prematurely. Potential margin requirements are discussed in the following section.

5.2.2.2 Potential Margin Requirements

An important factor to consider when hedging concerns the amount of margin that may need to be posted to cover futures market losses. This section provides an analysis of the potential margin requirements when routinely hedging hogs over the time period analyzed.

Figure 18 demonstrates the magnitude of maximum margin requirements that would have been required when routinely hedging with the live hog futures contract. Interest on the potential margin requirements is not included in this figure. Once again it was assumed that the futures contract volume exactly matched the volume of pigs being sold per week.

Figure 18. Real Potential Margin Requirements (1995 Dollars)

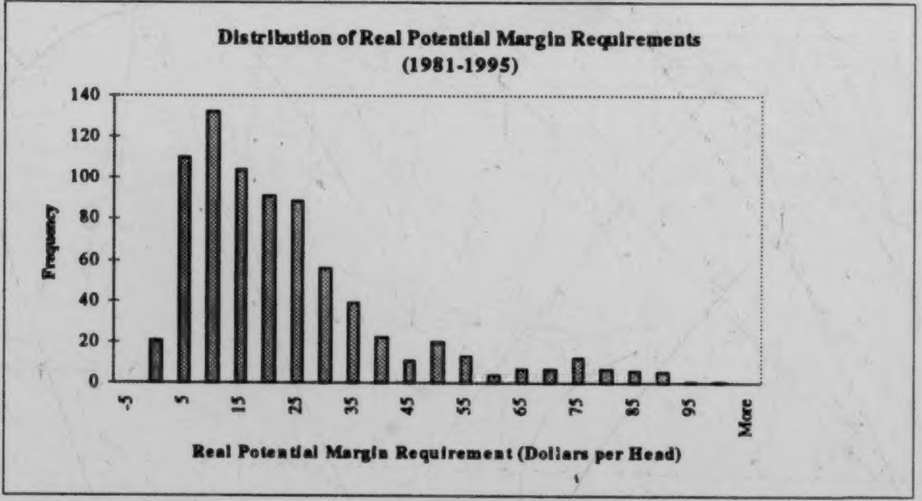


Figure 18 illustrates the potential for very large margin calls being issued to one routinely hedging hogs. In many cases the margin calls exceed 30 real dollars per hog marketed, and the maximum potential margin call found in this simulation was 96.50 real dollars per head. Considering this simulated operation markets approximately 132 hogs per week, margin requirements could reach as high as 12,738 real dollars for one pen, placing large demands on cash flow during these periods. It is also stressed that interest generated in margin accounts can amplify losses accrued with a losing hedge.

Results from the routine hedging simulation indicate that this strategy may not be an acceptable alternative to cash marketing. Although routine hedging reduced the variability of returns, mean returns were also reduced. In many cases, a widening of the basis resulted in large losses being incurred. Also, the routine hedging strategy hedged whether or not the forecasted profit was positive. Such a strategy can result not only in large losses to the producer, but also in the large margin calls being issued in times when the futures price is increasing. As a result, the routine hedging simulation demonstrates that routinely hedging production probably will not yield results desirable to producers.

The potential for large margin requirements serves as a deterrent for many considering hedging. Selectively hedging hogs may reduce the potential for large margin requirements by placing hedges only when the futures market is at a level where an estimated target profit exists and the futures market is exhibiting a pattern that is downward trending. This leads to the next section which evaluates several different selective hedging strategies and the risk and return tradeoff of the best selective hedging strategy compared to cash hedging and routine hedging.

5.2.3 Selective Hedging

Selective hedging was simulated to evaluate the potential for improving the risk and return tradeoff compared to cash marketing and routine hedging.

The mechanics of selective hedges are identical to routine hedging. The difference between selective hedging and routine hedging is that selective hedging involves hedging production at any time during the production period and only when it is forecasted to be profitable, whereas routine hedging involves hedging every pen of hogs at the same stage of production. Selective hedging is therefore a much more flexible marketing strategy compared to routine hedging because if the futures market is not at a favorable price or the futures market price is expected to increase, the producer does not have to hedge production.

Decision rules must be used by the producer to time the placement of a hedge when selectively hedging production. Many different decision rules and technical indicators exist, but this study used relatively basic guidelines in timing hedges. The decision to hedge was made through the use of moving averages and forecasted profit offered by the futures market.

Two different selective hedges were analyzed in this study. Each selective hedge required each of the two following conditions be met to hedge production

1. Forecasted profit (forward price minus projected break-even price) offered by futures market equaled or exceeded a target amount
2. Declining ten day moving average crossing fifteen day moving average

If the longer moving average exceeded the shorter moving average and the predicted net profit exceeded a target amount, a hedge was placed. In all cases, hedges placed were held until sale of the physical pen of hogs. No hedging was performed with four or fewer weeks to sale time. It was assumed that the additional benefits of hedging closer than four weeks to delivery would not outweigh the transactions costs (although transactions costs are not included in any of the hedging results). Profits were forecasted daily from farrowing to four weeks prior to sale.

5.2.3.1 Price Forecasting Models

Several variables must be forecasted to evaluate whether the futures market is offering a predicted profit greater than a target amount. This section provides detail as to the methodology used to forecast expected returns from a futures market price.

Defining predicted finished hog price at sale time as:

$$PHP_{t:t+(j-k),t+j} = \left[\frac{HF_{t:t+(j-k),t+j}}{PX_{t:t+(j-k),t+j}}\right] - PB_{t,t+j} \qquad \text{(Equation 37)}$$

where: $PHP_{t:t+(j-k),t+j}$ = forecast during production period of finished hog price at day t+j (finish) in Canadian dollars per pound liveweight

$HF_{t:t+(j-k),t+j}$ = futures price during production period for hog futures contract expiring closest but not prior to week t+j in U.S. dollars per pound liveweight

$PX_{t:t+(j-k),t+j}$ = forecast during production period of exchange rate at day t+j (defined as U.S. dollars to buy 1 Canadian dollar)

$PB_{t,t+j}$ = forecast at week t of basis at day t+j (remains static over production period) in Canadian dollars per pound liveweight

k = 28 days

predicted net profit can be calculated as:

$$PNP_{t:t+(j-k),t+j} = (PHP_{t:t+(j-k),t+j} * Q_{t+j}) - PTC_{t,t+j} \qquad \text{(Equation 38)}$$

where: $PNP_{t:t+(j-k),t+j}$ = forecast during production period of net profit per hog at day t+j

$PHP_{t:t+(j-k),t+j}$ = forecast during production period of finished hog price at day t+j in dollars per pound

Q_{t+j} = hog finishing weight in pounds

$PTC_{t,t+j}$ = forecast at day t (farrowing) of total costs per hog at day t+j (remains static over production period)

The first step in forecasting hog prices for the purpose of selectively hedging involved predicting the exchange rate, total costs per hog and basis at the time of sale.

5.2.3.2 Exchange Rate Forecast

This study used the current spot exchange rate as the predictor of the spot exchange rate at sale time. Although several different methods can be used to predict the future exchange rate, using the current spot exchange rate as a predictor of the future exchange has been shown to outperform more complicated forecasting models. Unterschultz (1991), Novak et al. (1992), Munro (1993) and Novak and Viney (1995) used the spot exchange rate as a forecast of future exchange rates. Therefore PX in Equation 37 is the spot exchange rate at the time of the forecast.

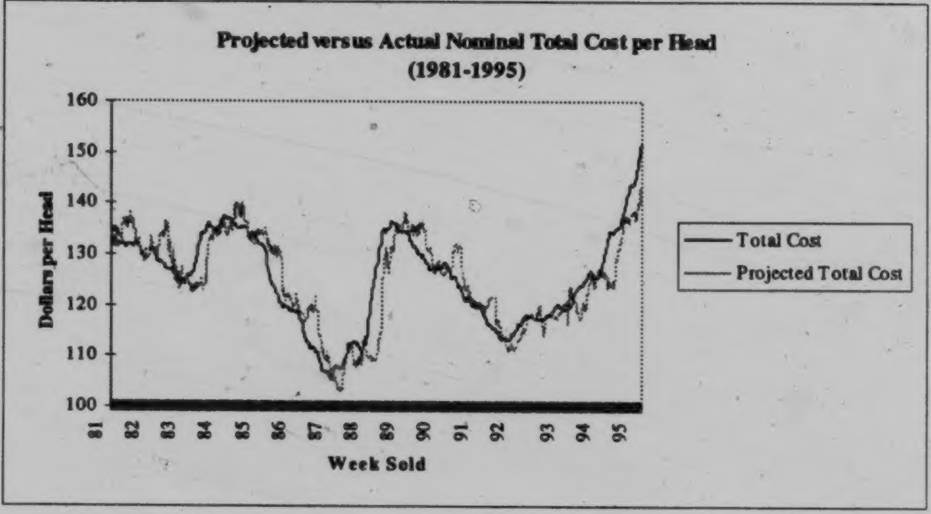
5.2.3.3 Total Cost Forecast

The forecasted total cost to bring one hog from farrowing to finish, PTC in Equation 38, is needed to forecast net returns. Forecasted total costs per hog at sale time were calculated by combining all input costs at farrowing with the required production function of the animal. Therefore, projected feed costs were calculated by combining feed input prices at farrowing with the feed requirements and rations for the hog through the different stages of growth. All other costs were incorporated into the total cost forecast through the value they were at upon farrowing. This forecast remained static for each pen of hogs, once a forecast of costs was made for a particular pen of hogs the forecast did not change over the time period that the pen remained in the operation.

The advantage of a cost forecast remaining static rests in lower computational requirements. A total of 758 pens of pigs were fed from farrow to finish, with each pen requiring 22 weeks on feed. Continually updating cost forecasts for each pen of pigs would require up to 18 (not hedging closer than four weeks to delivery) cost forecasts for each pen of pigs. It was decided that any gain in cost forecasting accuracy was outweighed by computational limitations.

The following figure represents the forecast of total costs made at sale time. The forecasts were made at farrowing, 25 weeks prior to sale. The projected costs seemed to forecast realized costs at sale time well, except during the periods of early 1987, late 1988 and early 1995.

Figure 19. Cost Forecasting Accuracy (Nominal Dollars)



5.2.3.4 Basis Forecast

Several different basis prediction models were developed and tested for cash price forecasting accuracy. The measure used to determine the most accurate cash price predictor was the Root Mean Square Error statistic. In all, eight different predictive models were tested. These were:

1. 52 week rolling average of nearby basis (MA1)
2. 156 week rolling average of nearby basis (MA3)
3. Current nearby basis (NBYB)
4. Rolling average of current, 52 week prior and 104 week prior nearby basis (AVG3)
5. Current basis multiplied by seasonal index average of 52 week prior, 104 week prior and 156 week prior basis (INDX) *

6. Nearby basis ARIMA (1,0,1) X (1,0,1) (ARIMA)*

*see Appendix C

A forecast of future cash prices for each of the basis prediction models was calculated as:

$$PHP_{t,t+j} = \left[\frac{HF_{t,t+j}}{PX_{t,t+j}}\right] - PB_{t,t+j} \qquad \text{(Equation 39)}$$

Two forecasts based on Alberta hog prices were also used to predict future cash prices and compared against the basis forecasting models for an optimal cash price forecast. The two simple cash forecast models were:

1. Current cash price (NBYC)
2. Eight week rolling average of cash (MAC)

Each model was compared using the Root Mean Square Error statistic. The Mean Square Error in forecasting future cash prices was calculated as follows:

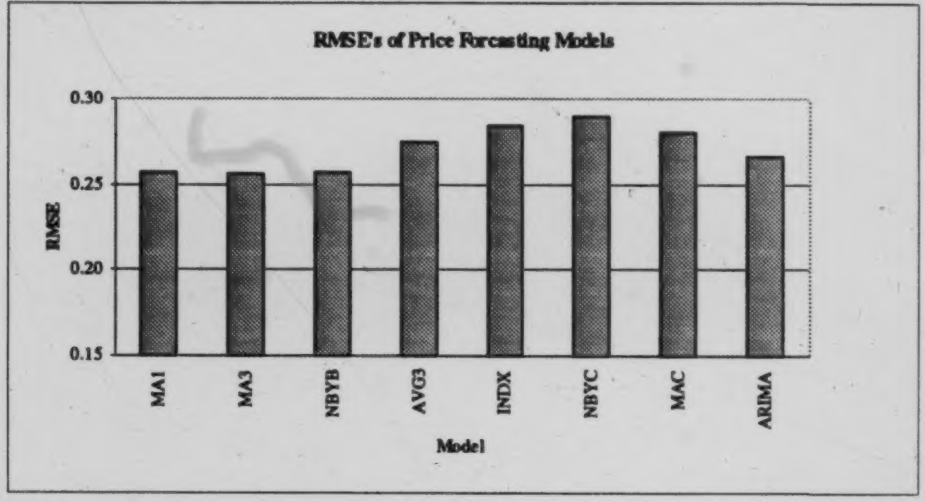
$$MSE = \frac{\sum_{i=1}^{n}(PHP_{t,t+j} - AHP_{t+j})^2}{n-1} \qquad \text{(Equation 40)}$$

where: $PHP_{t,t+j}$ = forecasted hog price at sale time
AHP_{t+j} = actual hog price at sale time

and the Root Mean Square Error in forecasting future cash prices was calculated as:

$$RMSE = \sqrt{MSE} \qquad \text{(Equation 41)}$$

Figure 20. Root Mean Square Error of Price Forecasting Models (Nominal Dollars per Kilogram Dressed)



All of the forecasting models proved to be close in forecasting ability. The MA1, MA3 and NBYB basis forecasting models were virtually identical in accuracy. Although seasonality was shown to exist in the basis through the significance of the coefficient for the seasonal autoregressive variable in the ARIMA (1,0,1) X (1,0,1) model (Appendix C), the INDX basis forecasting model did not perform as well as the previously mentioned models. It was speculated that one model did not forecast well due to changes in the basis pattern over time.

The 52 week rolling average of nearby basis was chosen to be used as part of the net profit forecast in the selective hedging strategies. Therefore, the required basis forecast in Equation 37, PB , was a 52 week rolling average of the nearby hog basis.

5.2.3.5 Selective Hedging Results

Two types of selective hedges were examined. They were:

1. 5-10-15 Selective Hedge = hedge if PNP > 5 Canadian dollars per pound liveweight (13.95 dollars per kilogram dresses) and 15 day moving average > 10 day moving average

2. 10-10-15 Selective Hedge = hedge if PNP > 10 Canadian dollars per pound liveweight (27.90 dollars per kilogram dressed) and 15 day moving average > 10 day moving average

The two selective hedging strategies resulted in the following real net revenue values and are compared with the cash marketing and routine hedging results. Up to a maximum of 758 pens of hogs could be hedged with these strategies.

Table 4. Comparison of Real Net Revenues - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens	% Pens Hedged
5-10-15 Selective Hedge	21.11	30.55	46.98	116.86	50	7	24.1	43
10-10-15 Selective Hedge	21.71	31.05	46.98	116.86	51	7	23.9	36
Cash Marketing	19.72	32.94	46.98	116.86	54	7	25.7	-
Routine Hedging	15.18	26.32	51.78	90.97	66	6	28.9	100

Although a higher mean and lower standard deviation of real net revenue was realized for several different selective hedges compared to cash marketing, periods of large losses occurred with both selective hedges (Table 4). In addition, improvements in the mean and standard deviation of returns were small which is similar to the selective hedging results of Brandt (1985) and Gore and Leuthold (1993). The maximum loss and gain under each selective hedging regime was identical to the largest loss when cash marketing and no reduction in the number of losses over 20 and 40 dollars per head were realized with the selective strategies. This is due to the fact that in certain times, the futures market never offered a large enough target profit to hedge or the target profit existed but the market was not trending in a direction that would trigger the moving average rule. This led to many pens of hogs being left unprotected over the feeding period, and large losses being realized with those pens. A slight reduction in the percentage of losing pens was observed.

As was expected, the 5-10-15 selective hedge resulted in more hedges being placed than the 10-10-15 selective hedge. This was because the 5-10-15 selective hedge required a smaller target profit than the 10-10-15 strategy to hedge. The 5-10-15 strategy hedged 43% of the pens and the 10-10-15 strategy hedged 36% of the pens (out of 758 pens marketed).

The time series of real net revenues and frequency distribution of real net revenues for the 10-10-15 selective hedge are shown in Figures 21 and 22, respectively.

Figure 21. Real Net Revenue per Head with 10-10-15 Selective Hedge (1995 Dollars)

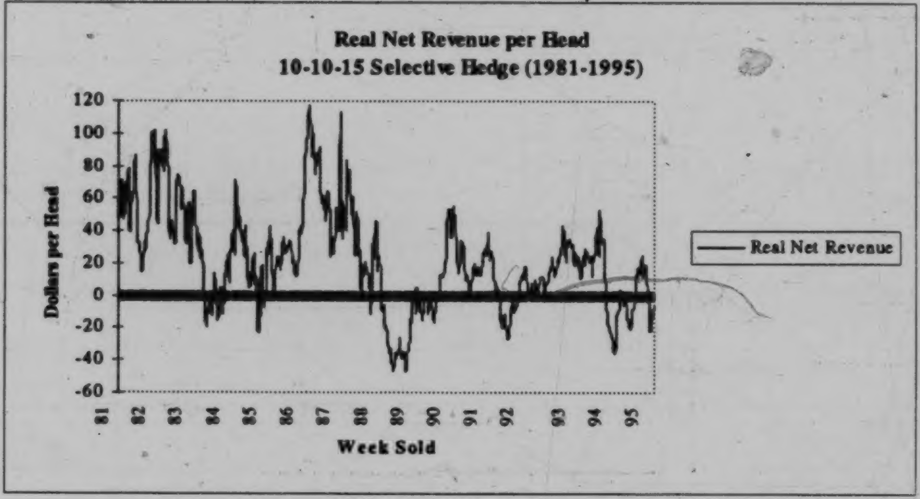


Figure 22. Distribution of Real Net Revenues with 10-10-15 Selective Hedge

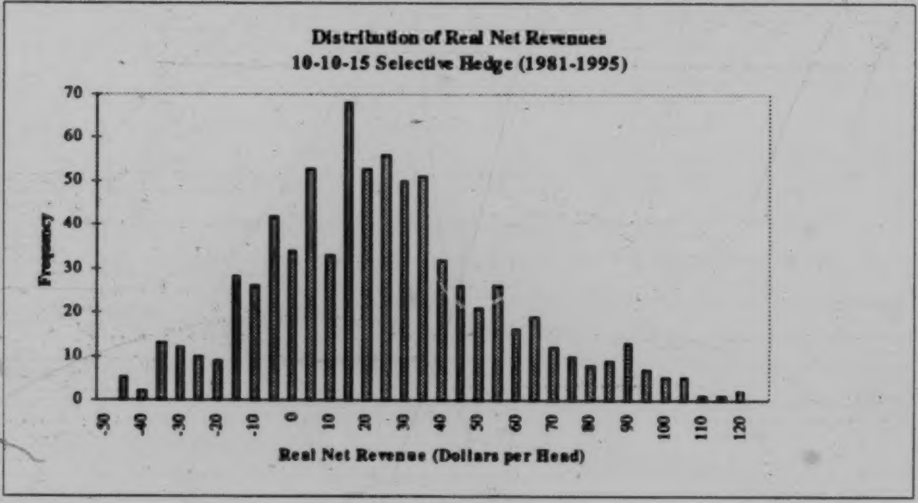
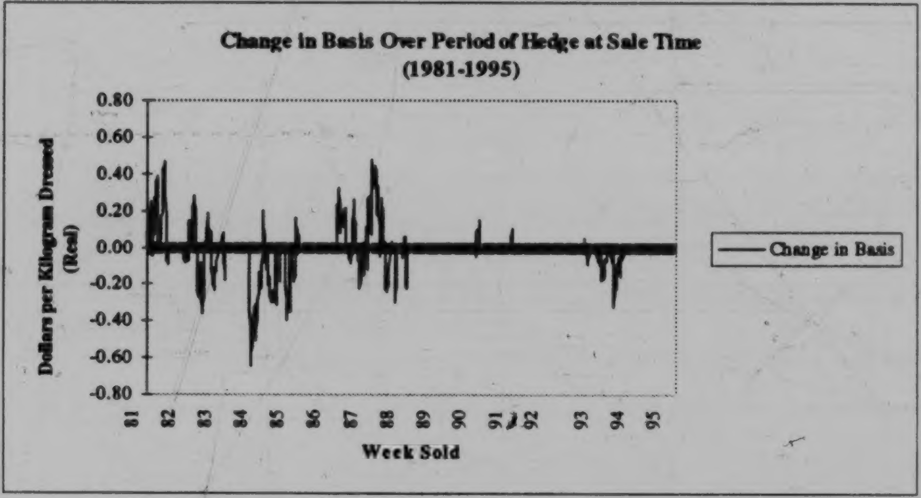


Figure 23 shows the basis change over the period of any hedges that were placed. Where no line exists, no hedge was placed.

Figure 23. Change in Real Basis over Hedging Period (1995 Dollars)



The selective hedging strategies provide results that may be interesting to producers wishing to increase average returns and reduce return variability, as long as they are not concerned with periodic large losses. Both selective hedging strategies resulted in a small increase in mean returns and a small decrease in the standard deviation of returns, compared to cash marketing. However, in many cases the markets did not offer the required target profit, resulting in several pens of hogs being left unhedged and incurring large losses on the cash market.

As with routine hedging, selectively hedging production resulted in basis risk over some of the hedges (Figure 23). This resulted in poor performance of some of the hedges, especially those during 1984 and 1985. This leads to the following section, which examines routinely forward contracting production in attempts to eliminate basis risk and not leave any pens of hogs exposed to the cash market.

5.2.4 Forward Contracting

The results from selectively hedging hogs were positive in terms of an improvement in the mean and standard deviation of real net revenues, but the problem of experiencing large losses was not eliminated. In many cases this was due to either basis risk being experienced with hedged or unhedged pens being exposed to an unfavorable cash market. Basis risk and price risk are eliminated with forward contracting, therefore it was hypothesized that routinely forward contracting production would result in a higher mean return, a lower variability of returns and a reduction in the frequency of large losses. Because the strategy was routinely executed, no pens were exposed to the cash market.

Selectively forward contracting production with the same decision rules as the selective hedging models was also hypothesized to improve mean returns and lower return variability as well as lower the frequency of large losses. Unlike routine forward contracting, selective forward contracting would not improve the maximum loss found under selective hedging because, using the same decision rules used to selectively hedge, the pen exposed to the largest loss would still be exposed to the cash market. As a result no selective forward contracting simulations were performed.

5.2.4.1 Routine Forward Contracting

Routinely forward contracting production involved selling each pen of hogs at farrowing for the forward price on that day, adjusted for premiums. The price at sale time was calculated as:

$$FP_{t:t+j} = \left[\left(\frac{HF_{t:t+j}}{X_{t:t+j}} - PB_{t:t+j}\right) * \frac{2.204lbs}{Kg} / 0.79\right] * Findress * Index$$

(Equation 42)

where: $FP_{t:t+j}$ = forecasted hog price at sale time in Canadian dollars per kilogram dressed
$HF_{t:t+j}$ = live hog futures price in U.S. dollars per pound liveweight
$X_{t:t+j}$ = spot exchange rate at time of forecast in U.S. dollars to buy one Canadian dollar
$PB_{t:t+j}$ = one year rolling average of nearby basis in Canadian dollars per pound liveweight
$Findress$ = 80% (hog dressing percentage)
$Index$ = 1.07 (hog index)

Routine forward contracting locks in the basis at farrowing. In this case the basis locked in was the forecasted basis. Locking in the basis eliminates any potential for a widening of the basis over the production period, resulting in zero basis risk to the producer. The party offering the forward contract consequently accepts all basis risk, which can not be eliminated through hedging. In return for accepting the basis risk, the party offering the forward contract receives a guaranteed supply of hogs.

The results of routinely forward contracting all 758 pens of hogs are presented in the following Figures and Table.

Figure 24. Real Net Revenue per Head - Routine Forward Contracting (1995 Dollars)

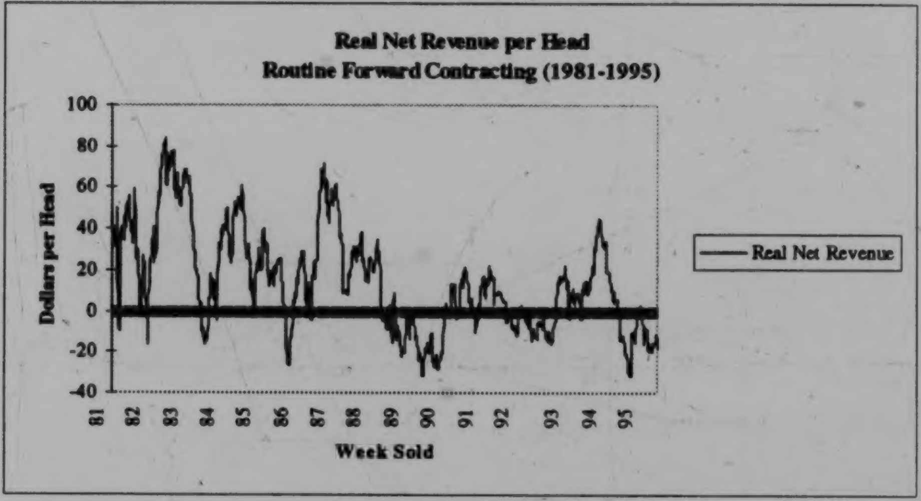


Figure 25. Distribution of Real Net Revenues - Routine Forward Contracting

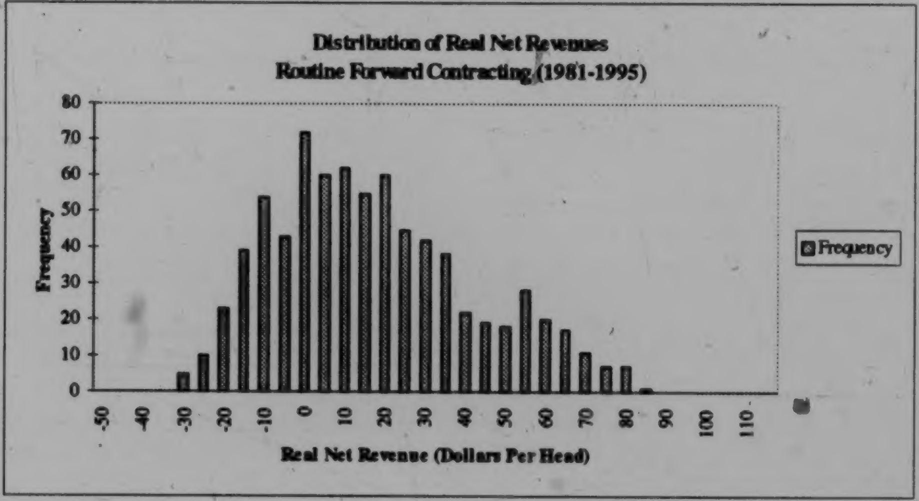


Table 5. Comparison of Real Net Revenues - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens	% Pens Contracted
Routine Forward Contracting	14.53	24.80	31.56	83.81	38	0	32.5	-
5-10-15 Selective Hedge	21.11	30.55	46.98	116.86	50	7	24.1	-
10-10-15 Selective Hedge	21.71	31.05	46.98	116.86	51	7	23.9	-
Cash Marketing	19.72	32.94	46.98	116.86	54	7	25.7	-
Routine Hedging	15.18	26.32	51.78	90.97	66	6	28.9	100

The results of routine forward contracting simulation indicate that this strategy may not be an acceptable alternative to cash marketing. The standard deviation of returns was reduced by over 6 dollars per head compared to cash marketing but unfortunately the mean of returns and percent of losing pens worsened with the routine forward contracting strategy. The maximum loss decreased in absolute value compared to cash marketing, but the maximum profit also decreased by over 30 dollars per head. Results from routinely forward contracting production were encouraging in terms of lowering the frequency of large losses. Losses greater than 40 dollars per head were eliminated and the number of losses greater than 20 dollars per head were somewhat reduced. This strategy may not be acceptable to producers who want to reduce large losses without greatly reducing mean returns.

Basis risk is eliminated with forward contracting and basis and exchange rate risk are the only risks present with routine hedging. The difference in returns between the two strategies was therefore due to basis and exchange rate risk. This study did not measure basis risk through forward contracting and routine hedging return comparisons due to complications arising from how the hogs sold incurred indexing premiums. Because the forward contracting price included index premiums in the final price, whereas the final price received when routine hedging included index premiums on the hogs sold on the cash market and no index premiums on hedge profits, a direct comparison of the two return series to measure basis risk was not appropriate. As a result no attempt to measure basis risk was made in this study.

5.3 Chapter Summary

Chapter 5 shows the results found from simulating a cash marketing strategy, a routine hedging strategy, several types of selective hedging strategies, and a routine forward contracting strategy. None of the hedging or forward contracting strategies resulted in a significant reduction in the frequency of large losses experienced by the producer. In the case of routinely hedging production, the producer often experienced a widening of the basis which severely affected profitability, and routinely hedged production regardless of the forecasted profit being offered. The lower returns observed with routine hedging may also be due to a risk premium existing in live hogs futures contracts. In the case of the selective hedging strategies, these losses were due to several pens of hogs being left unhedged and exposed to the cash market during periods when cash prices were low, and a widening of the basis over some of the hedges.

The routine forward contracting strategy did eliminate basis risk and slightly reduced the number of large losses, but returns were also reduced. In all cases, periodically high feed prices combined with a low hog price resulted in relatively large losses being incurred. The potential presence of risk premiums in distant hog futures contracts may also explain why mean returns were low with this strategy.

None of these strategies provide an acceptable alternatives to cash marketing, taking into account the safety-first criteria. The selective hedging strategies did improve the mean and reduce the standard deviation of returns, but at a price to the producer. This price included basis risk and pens being left unhedged, resulting in many large losses. The routine hedging and routine forward contracting strategies reduced mean returns and did not reduce large losses, and were therefore not considered as viable alternatives to cash marketing.

Chapter 6 develops a different type of hog market derivative instrument which can potentially reduce price risk to the producer. These instruments are short term window contracts, much like those currently used in Manitoba, with two major types of window contracts being simulated. The window contracts were priced off of the live hog futures contract and were simulated in order to examine their risk reducing properties.

6. Window Contracting

Simulation of marketing strategies such as routine hedging, selective hedging and forward contracting revealed that although certain strategies can increase mean returns and reduce income variability, a relatively large number of significant losses can still occur. As a result, window contracts were simulated to discover if these contracts can be used to maintain mean returns, reduce variability of returns and reduce or eliminate large losses compared to the other marketing strategies.

As was previously discussed in Chapter 4, window contracts provide a price window to the purchaser of the contract. The window contract is identical to both parties buying and selling options, with the contract provider guaranteeing the basis and exchange rate. The producer buys a put option from the contract provider and sells a call option to the contract provider. Gains or losses with a final price above the ceiling or below the floor price of the window may either be shared or not shared between writer and purchaser of the contract, depending on the contract terms. If losses are shared the producer gains price protection by sharing losses with the writer of the contract at delivery if the resulting price is below the floor price. If losses are not shared the writer absorbs all losses below the window floor. The ceiling price provides protection to the writer of the contract in the same manner.

Because window contracts are a forward contract in that they have zero value upon agreement, the floor and window prices must be fairly set so that neither party has an initial advantage. In order to fairly establish a window contract, a modified version of Wei's (1994) option pricing model was used. The rationale for using this option pricing model is as follows.

Forward contracts are established with a price that is the best forecast of the price at delivery. Because U.S. futures markets are the primary price discovery mechanism for hogs in the U.S., and Alberta is a price taker from the U.S. hog market, futures markets provide a means in which to forecast Alberta hog prices. Cash price forecasts made by adjusting the appropriate hog futures contract with the current spot exchange rate and a 52 week rolling average of nearby basis outforecasted two cash price forecasting models (Figure 20). Therefore the live hog futures contracts in conjunction with exchange rate and basis forecasts can be used to obtain a forward price of the Alberta hog price at some future point in time.

The first step in developing a window contract involves arbitrarily choosing a non-localized (not adjusted with basis) window floor price adjusted to Canadian dollars through a guaranteed exchange rate at the time the window is established. The floor price should be chosen so that the window is not unreasonably wide or narrow. The fixed floor price of the window contract is identical to the fixed strike price of a cross-currency option, guaranteed in Canadian dollars, on the Canadianized hog futures contract (CME live hog futures contract adjusted to Canadian dollars). Once the floor is chosen, the critical part of establishing the window is where to set the ceiling price to give the window contract zero value.

One can find the value of a cross-currency put option on the Canadianized hog futures market using the modified option pricing model (section 4.2.2). The modified option pricing model prices European options, which can not be exercised prior to maturity. This approach is justified because the producer can not deliver hogs on the window contract prior to maturity of the contract. Once a put option value has been calculated, fairly setting the non-localized ceiling price involves equating the value of the cross-currency put option with the value of a cross-currency call option. Given the Canadianized futures price and the value of the call, one can numerically solve through the modified call option pricing model to find the strike price that would yield a cross-currency call option with a value equal to the cross-currency put option. Because the put option value equals the call option value, the window contract has zero initial value. Adjusting both the floor and ceiling prices with the forecasted basis localizes the window contract to represent a contract being offered in Alberta.

Black's (1976) option pricing model has widely been recognized as a model that, assuming log normality of prices, fairly prices options. As a result, if log normality of prices is assumed in this study, using the modified version of this option pricing model should yield non-localized ceiling prices that fairly establishes the window contract. The option pricing model has been criticized for mispricing options with strike prices very out or in the money if prices do not demonstrating perfect lognormality (Hull 1995) If the tails of the true distribution are fatter than the tails of the lognormal distribution, deep in or out of the money options will be underpriced. Conversely, if the tails of the true distribution are thinner than the tails of the lognormal distribution, these options will be overpriced. However no other simple option pricing model exists as an alternative to Black's model.

This study simulated several different types of window contracts developed using one of two criteria. The first group of window contracts involved establishing a window based on a confidence interval around the forecasted price at sale time, using the lower bounds of the interval to establish the window floor. The second group of window contracts were established using the projected break-even price at sale time minus a target profit amount to establish the window floor price at farrowing. The Chicago Mercantile Exchange live hogs futures contract and Canadian dollar futures contracts were used in conjunction with a modified version Wei's (1994) option pricing model to establish both groups of windows. Canadian dollar futures contracts are traded on the Chicago Mercantile Exchange and the contracts are traded on four delivery months; March, June, September and December.

6.1 Routine Window Contracting Using Confidence Intervals to Set Windows

The first step in establishing a price window involved choosing a window floor price. For the first group of window contracts examined in this study, setting the window floor price involved establishing a confidence interval around the non-localized futures price at delivery, and using the basis adjusted lower bounds of the confidence interval as the window floor price. Using a confidence interval approach incorporates what percent of the time one would expect the floor price to be below the Canadianized futures price at contract maturity. A 50% confidence interval approach meant that, at contract maturity, the floor price of the cross-currency option was expected to be higher than the Canadianized futures price 25% of the time. Using a 25% confidence interval approach meant that the floor price was expected to be higher than the Canadianized futures price 37.5% of the time. As a result the 25% confidence interval approach should result in more risk sharing than the 50% confidence interval approach because the floor price is expected to be higher than the Canadianized futures price at contract maturity more frequently. Three widths of confidence intervals were arbitrarily chosen. These confidence intervals were of 25%, 50% and 75% in level of confidence.

The Canadianized hog futures price was calculated as follows:

$$CHF_{t,t+j} = \left(\frac{HF_{t,t+j}}{X_{t,t+j}} \right) \quad \text{(Equation 43)}$$

where: $CHF_{t,t+j}$ = Canadianized hog futures price at farrowing in dollars per pound liveweight

$HF_{t,t+j}$ = live hog futures price at farrowing in U.S. dollars per pound liveweight

$X_{t,t+j}$ = spot exchange rate at farrowing used as forecast of exchange rate at sale time in U.S. dollars to buy one Canadian dollar

Assuming that prices are lognormally distributed and follow the stochastic process discussed in Appendix D (Unterschultz 1996) and by Hull (1993, 207-240), the lower bound of a $(100-\alpha)$ confidence interval to establish a window floor price was calculated as follows:

$$Floorp_i = CHF_{t,t+j}e^{\left(\frac{\sigma_{i,X}^2}{2}-\frac{\sigma_{i,HF}^2}{2}\right)\tau - Z\sigma_{i,HF,X}(T_i-t_i)} \qquad \text{(Equation 44)}$$

where: $Floorp_i$ = non-localized window floor price in Canadian dollars per pound liveweight
$\sigma_{i,X}$, $\sigma_{i,HF}$, and $\sigma_{i,HF,X}$ as defined in section 4.2.2.1
$T_i - t_i$ = time to expiration of contract in years
$Z = \frac{\alpha}{2}$ critical value from standard normal distribution

Once the floor price was established, the option value for a cross-currency put with a strike price equal to $Floorp_i$ and current Canadianized futures price of $CHF_{t,t+j}$, along with the prevailing interest rate and volatilities calculated as above, was found using the modified version of Wei's (1994) option pricing model (see sections 4.2.2 and 4.2.4). A corresponding strike price above $CHF_{t,t+j}$ for a cross-currency call option was then found through repeatedly entering different strike prices into the modified option pricing model until the call option premium from the iteration equalled the put option premium. The strike price of the call option was the resulting non-localized ceiling price of the window, denoted as $Ceilingp_i$.

Once the ceiling and floor prices were calculated, they were adjusted by the forecasted basis to localize the window in the following manner:

$$UWP_i = \left(Ceilingp_i - PB_{t,t+j}\right) * \frac{2.204lbs}{Kg} / 0.79 \qquad \text{(Equation 45)}$$

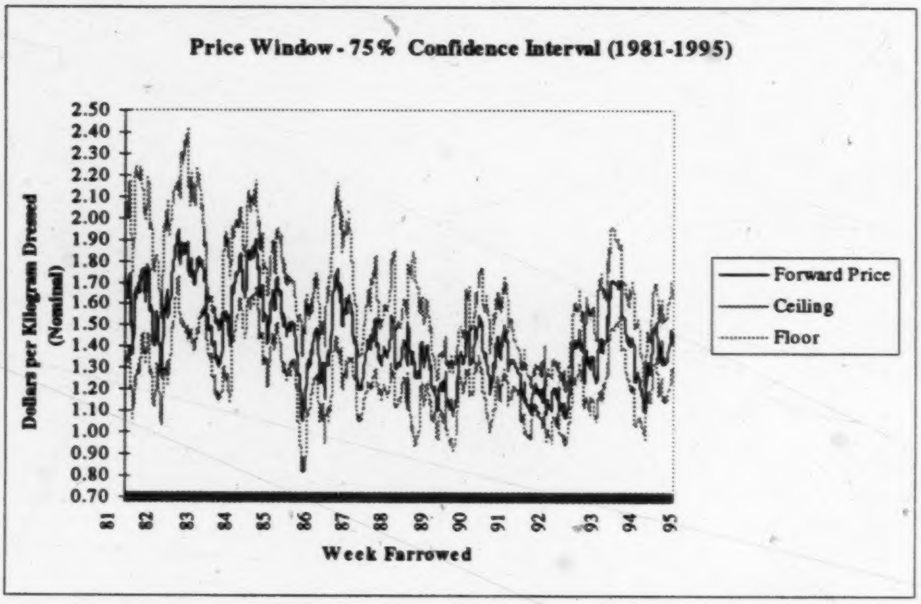
and

$$LWP_i = \left(Floorp_i - PB_{t,t+j}\right) * \frac{2.204lbs}{Kg} / 0.79 \qquad \text{(Equation 46)}$$

where: UWP_i = final ceiling price of window contract in dollars per kilogram dressed
LWP_i = final floor price of window contract in dollars per kilogram dressed
$PB_{t,t+j}$ = 52 week rolling average of nearby basis in dollars per pound liveweight (guaranteed in contract)

The following figure provides an illustration of the price window established using a 75% confidence interval around the forward price at farrowing. The Canadianized futures price is adjusted by the forecasted basis to represent the forecasted cash price (forward price) that the localized window encompasses.

Figure 26. Price Window Established Using 75% Confidence Interval (1981-1995)



Price windows established using a 25% and 50% confidence interval about the Canadianized hog futures price follow the general appearance as the 75% confidence interval. The difference between the three types of window contracts is the width of the windows. The ceiling and floor price of a window generated with a 25% or 50% confidence interval more closely bound the forward price than the ceiling and floor price established with a 75% confidence interval.

The maximum and minimum window widths of the window contracts established using three different confidence intervals around the Canadianized futures price are presented in the following table. The width of the window was calculated as $UWP_i - LWP_i$.

Table 6. Maximum and Minimum Window Widths (1981-1995)

	25% Window	50% Window	75% Window
Maximum Window Width ($/kg dressed)	0.34	0.62	0.99
Minimum Window Width ($/kg dressed)	0.04	0.09	0.15

Once the price windows were established, the returns that would have been realized from routinely window contracting hogs were simulated using 25%, 50% and 75% confidence intervals to establish the window floors. The routine window contract involved the producer accepting the terms of the window contract at farrowing each week, regardless of the prices offered in the window contract. Each new window was updated weekly according to the live hog and Canada dollar spot and futures prices, volatilities and interest rate parameters prevailing each week.

Gains or losses from window contracting were either shared equally between the producer and writer of the contract or not shared at all, resulting in two different versions of risk sharing being simulated. A detailed explanation the two versions of risk sharing is provided below.

1. No Sharing Agreement
    - If Alberta Index 100 price at sale time > UWP_i, producer receives UWP_i
    - If Alberta Index 100 price at sale time < LWP_i, producer receives LWP_i
    - If LWP_i < Alberta Index 100 price at sale time < UWP_i, producer receives Alberta Index 100 price
2. 50/50 Sharing Agreement
    - If Alberta Index 100 price at sale time > UWP_i, producer receives $\left(UWP_i + AlbertaIndex100price\right)/2$

- If Alberta Index 100 price at sale time < LWP_i, producer receives

  $\left(LWP_i + AlbertaIndex100price\right)/2$

- If LWP_i < Alberta Index 100 price at sale time < UWP_i, producer receives

  Alberta Index 100 price

In all cases, the producer received premiums for marketing hogs indexing at 107.

All 758 pens of hogs were contracted with each window contracting strategy. The results from routinely contracting each pen of pigs for 175 days (birth to finish), using windows established with one of three different confidence intervals were as follows (it should be stressed that the percent figures used to describe the type of window contract taken only illustrate the confidence interval used to find the window floor, not the window ceiling):

Table 7. Comparison of Real Net Revenues - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens	% Window Contracts Taken
Routine 25% Window (S)	17.26	25.80	38.46	88.29	31	0	26.6	100
Routine 50% Window (S)	17.56	26.97	43.08	94.99	37	3	25.3	100
Routine 75% Window (S)	18.10	28.64	46.59	104.29	46	4	25.2	100
Routine 25% Window (NS)	14.82	**23.26**	**33.98**	87.20	30	0	29.4	100
Routine 50% Window (NS)	15.40	**23.69**	39.78	88.94	**24**	**0**	27.8	100
Routine 75% Window (NS)	16.49	25.75	46.59	103.21	32	3	26.6	100
Routine Forward Contracting	14.53	24.80	31.56	83.81	38	0	32.5	-
5-10-15 Selective Hedge	21.11	30.55	46.98	**116.86**	50	7	24.1	-
10-10-15 Selective Hedge	**21.71**	31.05	46.98	**116.86**	51	7	**23.9**	-
Cash Marketing	19.72	32.94	46.98	**116.86**	54	7	25.7	-
Routine Hedging	15.18	26.32	54.80	91.05	66	6	28.9	-

*Note: S = gains or losses shared equally between producer and contract provider
NS = gains or losses not shared between producer and contract provider

Table 7 illustrates the returns found through the various window contracting strategies. The means of real net revenues were reduced with the window contracting strategies compared to the cash marketing results. The 25% and 50% no share strategies worked well in reducing return variability; with both strategies the standard deviation of returns were approximately 9 dollars less than the standard deviation of cash marketing returns. The maximum loss and maximum gain for all but the 75% window strategies were reduced in absolute value from cash marketing, as were the frequency of observing losses over 20 and 40 dollars per head. Once again it was observed that the large losses of 1988, 1989 and 1994, 1995 were present when window contracting (Figure 27), although the large losses of 1992 were reduced in absolute value compared to cash marketing. The percentage of losing pens did not decrease compared to marketing pigs on the cash market. This indicates that many of the pens were still losing money, although the magnitude of many of the losses were decreased in absolute value.

The 50% window contracts provided a more beneficial price window to the producer than windows established using 25% and 75% confidence intervals to set the window floor. The no share 25% window strategy so severely limited upside potential that more losses of 20 dollars per head were incurred than the no share 50% window strategy, and returns were lower with the 25% strategies. The 75% windows were too wide and did not provide effective downside protection, even with a no share agreement.

Not sharing gains or losses, compared to a 50/50 sharing agreement, decreased both the mean and standard deviation of revenues. It also decreased the maximum loss, maximum profit and frequency of losses greater than 20 dollars per head. Interestingly, not sharing gains or losses increased the percentage of losing pens. These results show that not sharing more extremely truncates both the upper and lower ends of the distribution than a 50/50 agreement, and there was a cost in doing so through a lower mean return. The reason for this was because slightly more gains were eliminated than losses when not sharing. Although the differences between the two types of sharing are negligible, this study focuses on the no sharing agreements because of the benefit of knowing the minimum price to be received with certainty. The 50/50 sharing agreements do provide some downside protection, but during a period when hog prices at sale are much lower than expected, the final price received may still be unacceptable.

The routine 50% window contracting strategy with no sharing of gains or losses provided the greatest change in the lower end of the revenue distribution compared to cash marketing (Figure 28). The change in the lower end of the distribution provides results desired with a risk management strategy. Losses in excess of 20 dollars per head were greatly reduced and losses in excess of 40 dollars per head were eliminated. Although this strategy resulted in a lower mean return that was similar to the mean return from routine hedging, the standard deviation was reduced by 9 dollars per head compared to cash marketing. The maximum loss was reduced by approximately 7 dollars per head, although the maximum gain was also reduced by almost 30 dollars per head. This indicates that the upper end of the distribution was truncated as well, which was the price paid for protection against large losses.

Figure 27 demonstrates the returns from the 50% window contracting (NS) and cash marketing strategies. It is evident that this strategy had the effect of both reducing large gains and large losses.

Figure 27. Real Net Revenues per Head - Routine 50% Window Contracting (NS) and Cash Marketing Strategies (1995 Dollars)

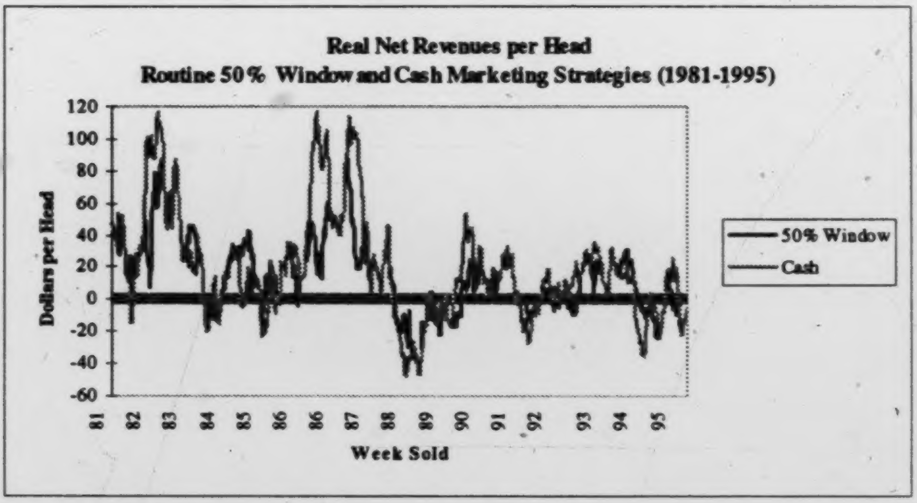
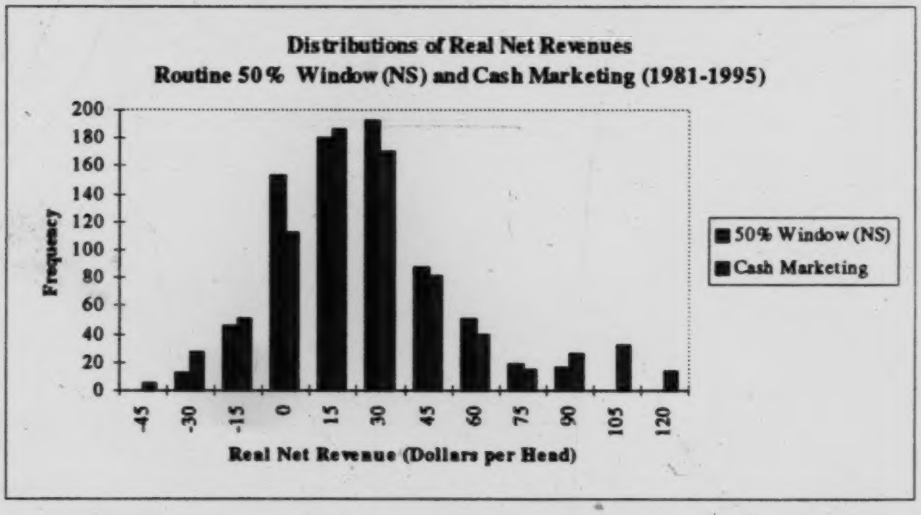


Figure 28. Comparison of Distributions of Real Net Revenues - Routine 50% Window Contracting (NS) and Cash Marketing Strategies



Due to the nature of the window contract, the potential to gain from a cash market price that is higher than the ceiling price is partially or completely eliminated. This is due to the producer accepting a reduction in the impact of favorable market moves in return for downside market protection. As a result, the lower standard deviation reflects not only a reduction in large losses, but also a reduction in large gains. The reduction in the ability to gain from high prices reduced mean returns as well.

Part of the reason why losses were still evident in 1988, 1989 and 1994, 1995 is that input costs were not controlled. Regardless of the output price protection being taken by the producer, if this protection does not cover costs, losses will still be incurred. During the time periods previously mentioned, input costs were relatively high. The window contract provided a degree of protection in the hog market, but the floor price did not necessarily exceed the break-even price. This led to a lower variability in the hog price being received by the producer, but high feed prices resulting in losses still being incurred during those periods when the final hog price received did not cover the break-even price. As a result, a new window contracting strategy was developed which attempted to establish the window floor price at or near the projected break-even price.

6.2 Routine Window Contracting Using Projected Break-even Price to Set Windows

The results from section 6.1 suggest that using window contracts developed with a methodology that ignores the costs of producing results in periods where a combination of high feed costs and low hog prices can lead to large losses being incurred by the producer. As a result, a second group of window contracts were developed that incorporate a projected break-even cost into the window pricing methodology.

The second group of window contracts evaluated were those established using the projected break-even price at sale time minus some target amount to establish the window floor price at farrowing. It was hypothesized that doing so would create a window that gave the producer a greater chance of covering costs at sale time, reducing the number of large losses incurred by the producer. These windows would establish a floor price high enough to provide protection when the hog market was low and feed costs were high. The projected break-even price at sale was calculated using the projected break-even total cost per pig as calculated in the selective hedging section (5.2.3.3), divided by the hog finishing weight, or:

$$BEP_{t,t+j} = \frac{PTC_{t,t+j}}{Outwt * \left(\frac{2.204 lbs}{Kg}\right)} \qquad \text{(Equation 47)}$$

where: $BEP_{t,t+j}$ = local projected break-even price at sale time in dollars per pound liveweight

$PTC_{t,t+j}$ = local projected total cost per pig

$Ouwt$ = hog finishing liveweight in kilograms

The non-localized window floor price (i.e. strike price in the modified put option formula) was then calculated as:

$$Floorp_i = BEP_{t,t+j} - t\arg et + PB_{t,t+j} \qquad \text{(Equation 48)}$$

where: $t\arg et$ = adjustment to lower window floor below projected break-even cost in dollars per pound liveweight

$PB_{t,t+j}$ = 52 week rolling average of nearby basis in dollars per pound liveweight

The basis was added to $BEP_{t,t+j} - t\arg et$ to obtain a non-localized strike price for the cross-currency put option. The next step involved finding the cross-currency put value associated with a strike price of $Floorp_i$. This involved using the modified version of Wei's (1994) option pricing model. The non-localized window ceiling price, $Ceilingp_i$, was then found by iteratively solving for the strike price of a cross-currency call yielding a cross-currency call option value equal to the cross-currency put option value. The window was adjusted with the projected basis to localize the window contract to the producer.

$$UWP_i = \left(Ceilingp_i - PB_{t,t+j}\right) * \frac{2.204lbs}{Kg} / 0.79 \qquad \text{(Equation 49)}$$

and

$$LWP_i = \left(Floorp_i - PB_{t,t+j}\right) * \frac{2.204lbs}{Kg} / 0.79 \qquad \text{(Equation 50)}$$

If the put strike price, $Floorp_i$, is close to the Canadianized futures price, the window will be narrow. Conversely, if the put strike price is distant from the Canadianized futures price, the window will be wide (Figure 31). One problem was encountered, however, when designing these contracts. The problem with using a projected break-even price in setting the window floor price was that periodically $Floorp_i$ exceeded the Canadianized futures price. The put option, and resulting call option, were in-the-money and the window had a floor price above the ceiling price (Figure 29). As a result, the producer did not have a reasonable window contract to take when the window was inverted (Figure 30).

Figure 30 shows one potential payoff scenario to the producer when the offered window is inverted. In the case of the no sharing agreement, the producer will not make a positive profit. With the 50/50 sharing agreement, the producer will only make a profit if the hog price at delivery is very high. Inverted window contracts thus do not offer a reasonable price/profit payoff to the producer and are not a viable risk management instrument. As a result, a minimum price contract was developed as an alternative to window contracting when the offered window contract was inverted.

Figure 29. Payoff When Put and Call Options are In-the-Money (Inverted Window)

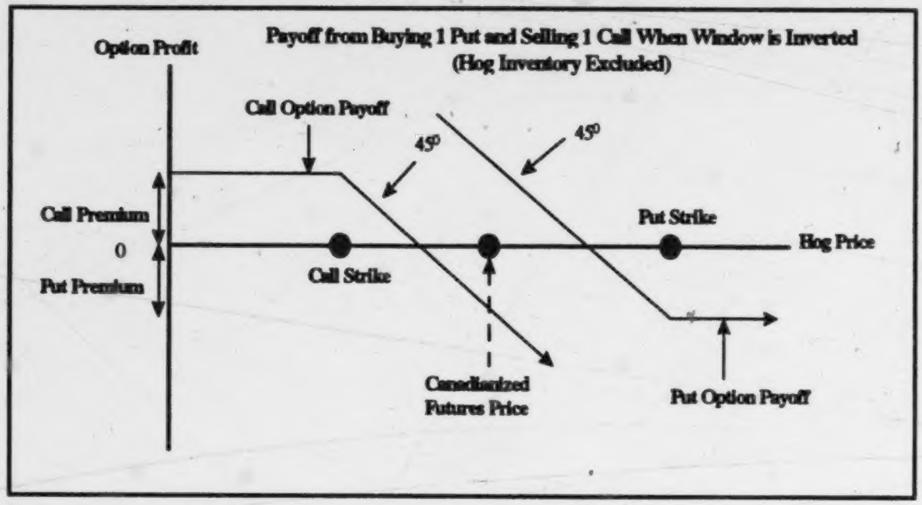
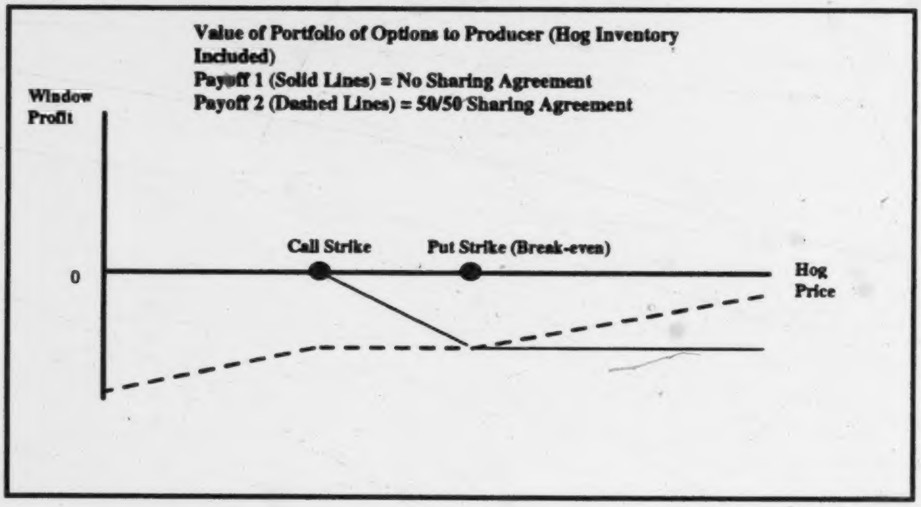

Option Profit
Payoff from Buying 1 Put and Selling 1 Call When Window is Inverted
(Hog Inventory Excluded)
Call Option Payoff
45°
45°
Call Premium
0
Put Premium
Put Strike
Hog Price
Call Strike
Canadianized
Futures Price
Put Option Payoff

Figure 30. Payoff to Producer Taking Inverted Window Contract


Value of Portfolio of Options to Producer (Hog Inventory Included)
Payoff 1 (Solid Lines) = No Sharing Agreement
Payoff 2 (Dashed Lines) = 50/50 Sharing Agreement
Window Profit
Call Strike
Put Strike (Break-even)
0
Hog Price

6.2.1 Minimum Price Contract

In some time periods, the option strike price, $Floorp_i$, exceeded the Canadianized futures price when developing window contracts with a floor price based on a projected break-even price. This resulted in a call with a strike price, $Ceilingp_i$, below the Canadianized futures price. As a result, the window became inverted in certain time periods because the floor price of the window exceeded its ceiling price.

A minimum price contract was subsequently developed to substitute for the window contract when the offered window contract was inverted.

The minimum price contract involved the producer paying the writer of the contract a premium equal to the put price found with a strike price of $Floorp_i$, which guarantees the producer a cash floor price of:

$$Floorp_i - PB_{t,t+j} \qquad \text{(Equation 51)}$$

In the case where the producer purchased a minimum price contract instead of a window contract, the producer received a net price at sale time equal to:

$$NHP_{t+j} = Max\left[HP_{t+j}, Floorp_i - PB_{t,t+j}\right] \qquad \text{(Equation 52)}$$

where: NHP_{t+j} = net hog price realized at sale time
HP_{t+j} = Alberta cash price at sale time
$PB_{t,t+j}$ = 52 week rolling average of nearby basis in dollars per pound liveweight (guaranteed in contract)

The cost of the option per hog was calculated as the value of the in-the-money cross-currency put option with a strike price of $Floorp_i$ multiplied by the liveweight of the finished hogs in pounds, or:

$$\Pr emium_i = Put_i * Outwt * \left(\frac{2.204 lbs}{Kg}\right) \qquad \text{(Equation 53)}$$

where: $\Pr emium_i$ = minimum price contract premium in dollars per hog
Put_i = cross-currency put option premium in dollars per pound liveweight
$Ouwt$ = hog finishing liveweight in kilograms

The cost of this option was deducted from the net revenue per pig value. Charging the option premium on a per hog basis rather than deducting the premium from the gross price received avoids charging extra for hogs indexing over 100. For example if the option premium was deducted on a dollar per kilogram dressed basis from the gross hog price and the producer subsequently received indexing premiums on this net price for hogs indexing over 100, this has the effect of increasing the price of the option through multiplying the option premium by the indexing premium. In this study, the final price received by the producer included premiums due to the producer for selling pigs indexing at 107, excluding the price of the option. The option cost per pig was then deducted from the net revenue per pig value. This methodology follows current industry practices.

Several variations of the break-even window contracts were simulated, with the producer taking a minimum price contract during times when the break-even window contract was inverted. Each strategy was simulated with producers either sharing or not sharing with the contract provider in times of gains or losses when a break-even window contract was taken. In times when a minimum price contract was taken, the producer received either the guaranteed minimum price in the contract when the cash price fell below the guaranteed minimum price, or the cash price when the cash price exceeded the guaranteed minimum price. Also, each of the contracts were simulated with the producer either locking in or not locking in all costs at farrowing. When locking in all costs at farrowing, the following methodology was used:

$$Tot\cos t_{t+j} = PTC_{t,t+j} \qquad \text{(Equation 54)}$$

where: $Tot\cos t_{t+j}$ = total cost per pig at sale time
$PTC_{t,t+j}$ = projected total cost per pig at sale time (see section 5.2.3.3)

In other words, when locking in all costs at farrowing, the producer purchased enough inputs at farrowing to last until the hogs were sold.

The targets below the projected break-even price were arbitrarily set at 0, 0.03, 0.05 and 0.10 dollars per pound liveweight. The reason for using targets below the projected break-even price was to lower the strike price of the option and thus increase the number of times a non-inverted window was offered to the producer. All of the strategies simulated in this section involved the contract provider guaranteeing the projected basis in the contract taken by the producer. The strategies simulated were as follows:

1. Routine BE/MPC (S, LF)

   Window contracted production with the window floor set at the projected break-even price in times when window not inverted. If the window was inverted, the producer instead purchased a minimum price contract offering the projected break-even price as the floor price. Producer shared gains and losses 50/50 with contract provider and locked in all costs at farrowing.

2. Routine BE/MPC (S)

   Same as (1) except costs were not locked in by producer.

3. Routine BE/MPC (NS, LF)

   Same as (1) except gains and losses were not shared between producer and contract provider.

4. Routine BE/MPC (NS)

   Same as (1) except gains and losses were not shared between producer and contract provider and costs were not locked in by producer.

5. Routine BE-0.03/MPC (S, LF)

   Same as (1) except window contract floor price and price guaranteed in minimum price contract set at 0.03 dollars per pound liveweight (0.084 dollars per kilogram dressed) below projected break-even price (also in dollars per pound liveweight).

6. Routine BE-0.05/MPC (S, LF)

   Same as (1) except window contract floor price and price guaranteed in minimum price contract set at 0.05 dollars per pound liveweight (0.14 dollars per kilogram dressed) below projected break-even price.

7. Routine BE-0.10/MPC (S, LF)

   Same as (1) except window contract floor price and price guaranteed in minimum price contract set at 0.10 dollars per pound liveweight (0.28 dollars per kilogram dressed) below projected break-even price.

8. Routine MPC

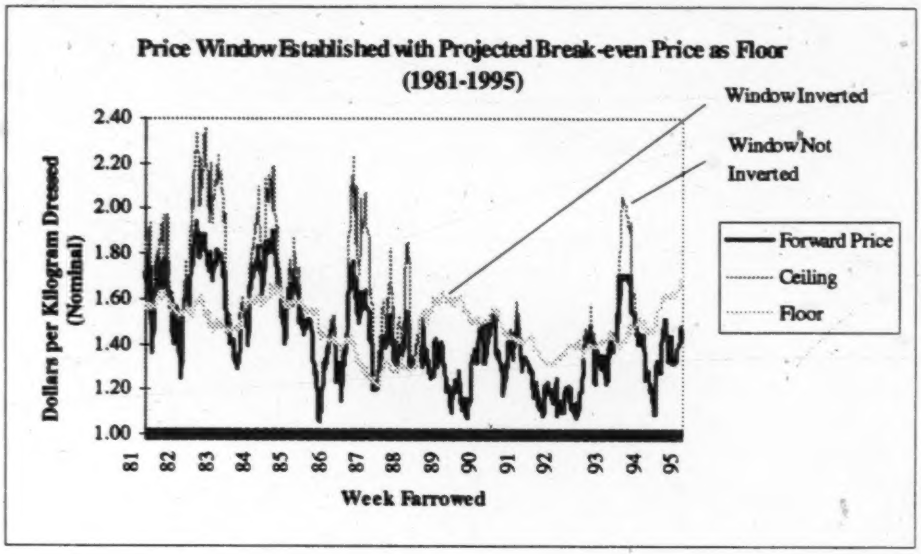
   Routinely take a minimum price contract guaranteeing the projected break-even cost, costs not locked in by producer.

9. Routine MPC (LF)

   Same as (8) except producer locked in all costs at farrowing.

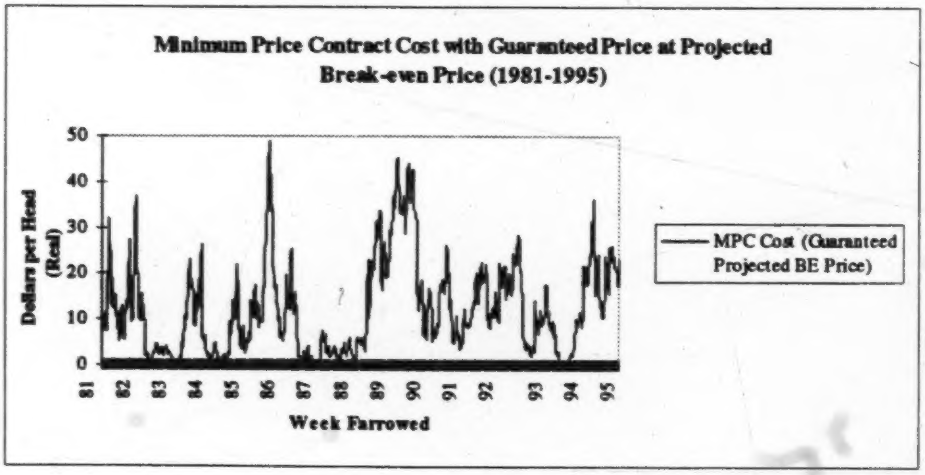
Figures 31 and 32 demonstrate the window being offered with the window floor price set at the projected break-even cost and the cost per head of the minimum price contract guaranteeing the projected break-even price, respectively. Figure 33 shows the window being offered when the floor price is set at 0.05 dollars per pound liveweight below the projected break-even cost.

Figure 31. Price Window Established with Projected Break-even Price as Floor (Nominal)



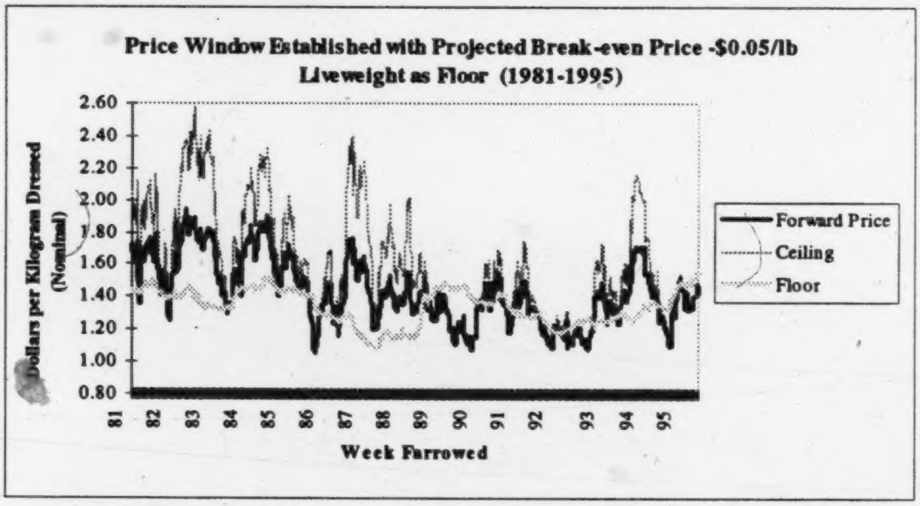
In the periods where the floor price lies above the forward price in Figure 31, the window was inverted and the producer instead purchased a minimum price contract. The cost of a minimum price contract offering the projected break-even price to the producer during any given time period is presented in Figure 32.

Figure 32. Cost of Minimum Price Contract per Head with Guaranteed Price at Projected Break-even Price (1995 Dollars)



It is evident that in many time periods, when the projected break-even price was well above the forecasted price at delivery, a contract guaranteeing the projected break-even price was very expensive. The producer was required to pay a high premium to be guaranteed the projected break-even price when taking a minimum price contract during those periods. In several cases the minimum price contract premiums exceeded 40 real dollars per head, or 5,280 real dollars per pen.

Figure 33. Price Window Established with Projected Break-even Price -$0.05/lb Liveweight as Floor (Nominal)



There are fewer inverted windows as the window floor price is dropped from projected break-even (Figure 31) to projected break-even minus a target amount (Figure 33). This is because lowering the window floor price reduced the number of times the forward price fell below the floor price. In Figure 31, 59% of the windows were inverted, while 32% of the windows were inverted in Figure 33. As a result the producer takes a window contract more times as the window floor price is decreased.

The results from simulating the various break-even and minimum price contracting strategies are presented in Table 8.

Table 8. Comparison of Real Net Revenues - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens	% Windows Not Inverted
Routine BE/MPC (S)	16.75	27.86	**27.80**	103.43	17	**0**	30.1	**41**
Routine BE/MPC (S, LF)	16.86	26.70	28.36	103.08	23	**0**	26.6	**41**
Routine BE/MPC (NS)	16.64	26.44	**27.80**	100.38	**14**	**0**	29.8	**41**
Routine BE/MPC (NS, LF)	16.75	25.20	28.36	99.97	23	**0**	26.3	**41**
Routine BE-.03/MPC(S, LF)	15.73	26.99	29.52	106.29	30	**0**	35.0	60
Routine BE-.05/MPC (S, LF)	15.36	27.91	30.29	107.82	34	**0**	35.9	68
Routine BE-0.10/MPC (S, LF)	16.14	29.29	33.12	109.55	79	**0**	30.1	90
Routine MPC	17.28	28.91	**27.80**	113.08	**14**	**0**	29.8	-
Routine MPC (LF)	17.39	27.81	28.36	112.25	23	**0**	26.3	-
Routine Forward Contracting	14.53	**24.80**	31.56	83.81	38	**0**	32.5	-
5-10-15 Selective Hedge	21.11	30.55	46.98	**116.86**	50	7	24.1	-
10-10-15 Selective Hedge	**21.71**	31.05	46.98	**116.86**	51	7	**23.9**	-
Cash Marketing	19.72	32.94	46.98	**116.86**	54	7	25.7	-
Routine Hedging	15.18	26.32	51.78	90.97	66	6	28.9	-

As with the window strategies developed using confidence intervals, the break-even window contracting strategies also resulted in lower mean returns per head than cash marketing. The minimum price contracting strategies only slightly decreased mean returns. Although all of the break-even window strategies resulted in lower return variability, none reduced the standard deviation of returns as much as the 25% and 50% no share window contracting strategies. It is evident that the BE/MPC(NS) and MPC strategies worked very well in reducing the number of large losses and the maximum loss experienced by the producer compared to cash marketing. In both cases the maximum loss and frequency of large losses were improved with these strategies over the 25% and 50% no share window contracting strategies. The maximum profit was 13 dollars higher for the MPC than the BE/MPC(NS) strategy. As the contract floor was lowered by increasing target amounts the number of large losses and the maximum loss increased. This was because the producer accepted a guaranteed minimum price below the projected break-even price.

The MPC and MPC(LF) strategies reduced the frequency of large losses and the largest loss incurred by the producer compared to cash marketing. The largest loss and frequency of large losses from the MPC and MPC(LF) strategies match those of the BE/MPC(NS) and BE/MPC(NS, LF) strategies, respectively, because the BE/MPC(NS) and BE/MPC(NS, LF) strategies took minimum price contracts when these losses occurred. The MPC and MPC(LF) strategies resulted in higher mean real net revenues than the matching BE/MPC(NS) and BE/MPC(NS, LF) strategies. This is because these window contracts have limited upside potential in maximum price received; the price received never exceeds the ceiling price (before premiums). Minimum price contracts do not limit this upside potential. Although the producer more frequently paid premiums with the MPC and MPC(LF) compared to the BE/MPC(NS) and BE/MPC(NS, LF) strategies (with no up front costs associated with taking a window contract), the unlimited upside potential outweighed the additional premium costs (Figure 32). The standard deviation of returns are also higher with the MPC strategies than with the respective BE/MPC(NS) and BE/MPC(NS, LF) strategies. Because the percentage of losing pens values are identical, the increase in standard deviation with the BE/MPC(NS) and BE/MPC(NS, LF) strategies can be attributed to the increase in frequency of profitable pens.

As the window floor prices were decreased by target amounts (BE-0.3/MPC (S, LF), BE-0.5/MPC (S, LF), BE-0.10/MPC (S, LF)), mean returns decreased and the standard deviation of returns, maximum loss, maximum profit, frequency of losses greater than 20 dollars per head and percentage of losing pens, increased. This was because the windows provided price protection at a lower price, and in many cases a minimum price contract at projected break-even would have been a better alternative than taking the window contract. The poor performance of these contracts suggests that they are inferior to the other window contracting strategies analyzed.

Going from no sharing to a 50/50 sharing strategy increased the mean and variability of returns, maximum profits and, for the two break-even window strategies that did not lock in costs, frequency of losses greater than 20 dollars per head. Changes in mean and variability of returns, as well as maximum profits were, however, small.

Locking in all costs at farrowing also slightly increased the mean and decreased the standard deviation of revenues. It also slightly increased the maximum loss, decreased the maximum profit, increased the frequency of pens losing greater than 20 dollars per head and decreased the percentage of pens losing money. The results of locking in feed costs at farrowing are thus ambiguous.

The advantage of all window and MPC strategies over the selective hedging strategies was that price protection was always taken by the producer. In many cases the selective hedging strategies left pens unhedged and exposed to the cash market, resulting in large losses.

The window and MPC strategies never left a pen exposed to the cash market, even though in several cases the producer had to pay a large amount for that protection. The mean of returns were not as high with the window strategies, but increasing the mean of returns with selective hedging came at a price, with a higher standard deviation and frequency of large losses compared to the window strategies.

Figures 34 and 35 present the real net revenues from the routine BE/MPC(NS) and MPC strategies, respectively. One can see from these figures that in many cases the BE/MPC(NS) and MPC strategies worked well in reducing large losses experienced with cash marketing. The large losses in 1986 with both strategies occurred due to extremely high minimum price contract costs during that period (Figure 32).

Figure 34. Real Net Revenue per Head - BE/MPC(NS) and Cash Marketing Strategies (1995 Dollars)

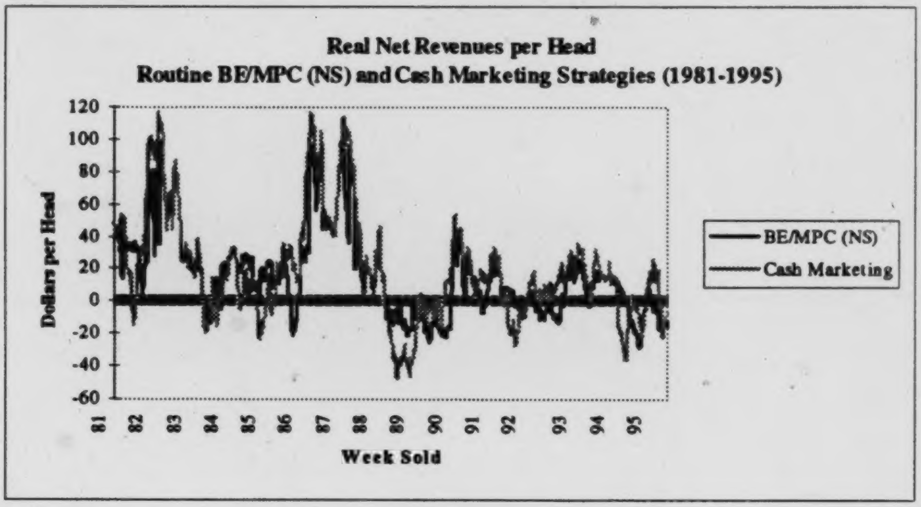
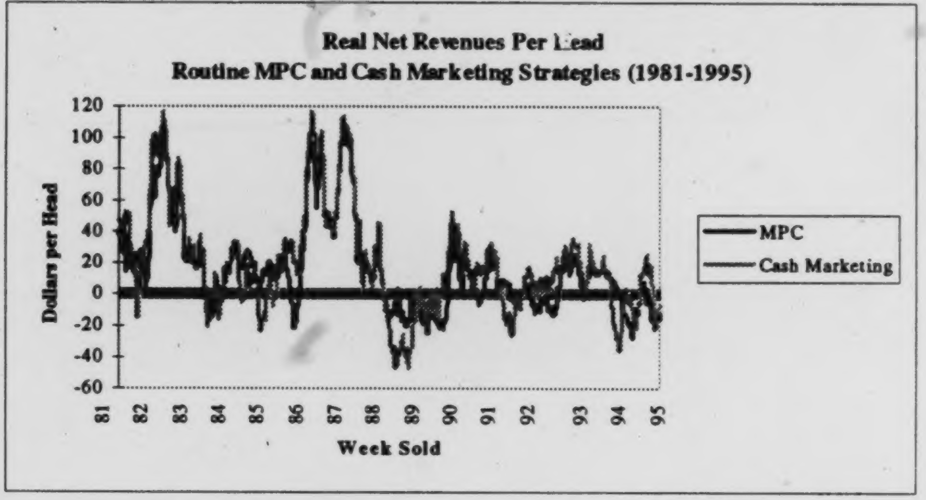
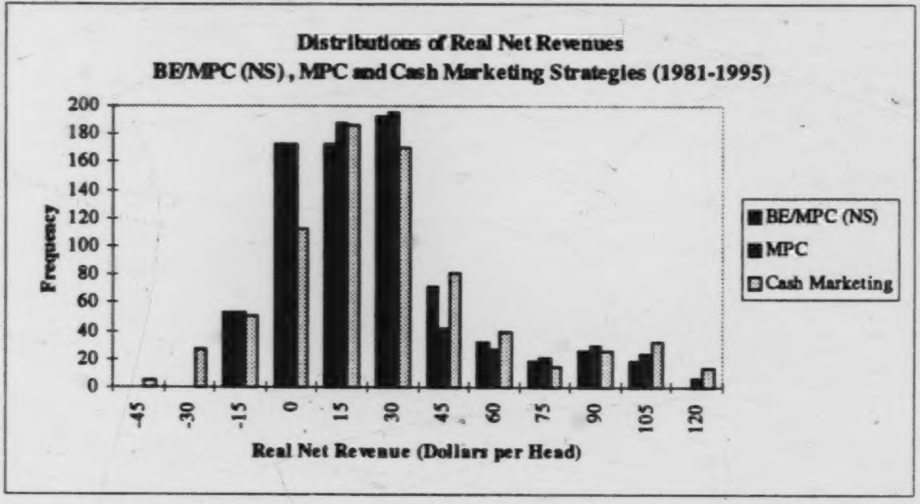


Figure 35. Real Net Revenue per Head - MPC and Cash Marketing Strategies (1995 Dollars)



Although the frequency of large losses and largest loss are the same between the MPC and BE/MPC(NS) strategies, the advantage of unlimited upside potential in the MPC strategy compared to the BE/MPC(NS) strategy is demonstrated in Figure 36. Figure 36 also demonstrates the effectiveness of both strategies in truncating the lower end of the return distribution, compared to cash marketing.

Figure 36. Comparison of Distributions of Real Net Revenues - BE/MPC(NS), MPC and Cash Marketing Strategies (1995 Dollars)



Developing window contracts on a forecasted break-even cost rather than a confidence interval did have the effect of reducing large losses more effectively. The mean and standard deviations of returns were higher for the BE/MPC strategies compared to the confidence interval windows. The difference in performance was, however, slight and both types of window contracts seemed to provide good downside protection, with the confidence interval windows sacrificing a little more in terms of average revenues.

It was apparent that the BE/MPC (NS) and MPC strategies worked well in truncating the lower end of the return distribution. The mean and standard deviation of returns were somewhat reduced, but the lower mean was probably an acceptable tradeoff given the large reduction in frequency of losses over 20 and 40 dollars per head. As a result, both strategies will probably be preferred to cash marketing by producers who are willing to sacrifice a portion of their returns in exchange for a strategy that provides good disaster insurance.

The problem with both strategies was that in certain time periods the minimum price contracts were very expensive. This leads to the next section, which evaluated whether waiting for a non-inverted window to appear, instead of taking a minimum price contract when the offered window was inverted, would provide adequate risk protection while reducing strategy costs.

6.3 Selective Window Contracting Using Projected Break-even Price to Set Windows

The routine break-even window/minimum price contracting strategies seemed to work reasonably well in reducing the frequency of large losses. It was hypothesized that although large losses were largely eliminated with these strategies, the options were an unnecessary expense in several cases and reduced mean returns. If the producer waited for a non-inverted window contract to appear instead of taking a minimum price contract when the window was inverted, the producer would save the cost of the option. The risk associated with this marketing strategy was that a non-inverted window would not appear, resulting in the pen of hogs being sold at an unfavorable price on the cash market. A selective window contracting strategy was simulated to evaluate the effectiveness of waiting for a non-inverted window contract to appear.

The selective window contracting strategy followed a pen of pigs from farrow to finish, with the producer contracting the pigs with a window contract established at the projected break-even cost minus a target value. If the window was inverted at farrowing, the producer continued to wait until eight weeks prior to sale for a normal window to appear. The producer made this evaluation once per week. If a non-inverted window did appear between farrowing and eight weeks prior to delivery, the window contract was taken and the pigs subsequently sold under the window contract. If all windows over this time span were inverted, the producer sold the pigs on the cash market.

Three types of window were simulated under both a 50/50 sharing and no sharing agreement . No costs were locked in at any time, because the previous section indicated doing so did not provide any clear advantage to the producer. The windows were updated weekly with new live hog futures prices and exchange rate forecasts. These strategies, as with the other break-even window strategies examined, required a basis, exchange rate, and break-even price forecast to establish the window. The 52 week rolling average basis forecast and the break-even price forecast remained static as in the selective hedging model, while the exchange rate forecast was updated weekly using the spot exchange rate. The three window contracts simulated set a window floor price at 0, 0.05 and 0.10 dollars per pound liveweight below the projected break-even price.

The results from the selective window contracting strategies are shown in Table 9

Table 9. Comparison of Real Net Revenues - Dollars per Head (1981-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens	% Windows Not Inverted
Selective BE Window (S)	18.55	27.33	46.98	113.34	47	6	21.8	59
Selective BE-.05 Window (S)	17.44	27.12	46.59	113.34	34	3	24.3	82
Selective BE-.10 Window (S)	17.24	29.18	46.39	113.34	41	2	28.6	95
Selective BE Window (NS)	17.38	24.40	46.98	113.34	42	6	20.1	59
Selective BE-.05 Window (NS)	15.17	**23.76**	46.59	113.34	26	3	**21.0**	82
Selective BE-.10 Window (NS)	14.76	27.19	46.39	113.34	28	2	34.0	95
Routine BE/MPC (S)	16.75	27.86	**27.80**	103.43	17	**0**	30.1	41
Routine BE/MPC (NS)	16.64	26.44	**27.80**	100.38	**14**	**0**	29.8	41
Routine Forward Contracting	14.53	24.80	31.56	83.81	38	**0**	32.5	-
5-10-15 Selective Hedge	21.11	30.55	46.98	**116.86**	50	7	24.1	-
10-10-15 Selective Hedge	**21.71**	31.05	46.98	**116.86**	51	7	23.9	-
Cash Marketing	19.72	32.94	46.98	**116.86**	54	7	25.7	-
Routine Hedging	15.18	26.32	51.78	90.97	66	6	28.9	-

The results from the selective window contracting strategies show that these strategies would not be beneficial to a producer (Table 9). Selective window strategies with a floor price equal to the projected break-even price have higher mean net revenues and maximum profits and slightly lower standard deviations of revenues than the BE/MPC strategies. The selective strategies also appear to provide little disaster insurance to the producer. The maximum loss and frequency of losses greater than 20 dollars per head are all larger with the selective compared to the BE/MPC strategies; losses over 40 dollars per head are also incurred. The selective BE-0.05 (NS) strategy worked well in reducing the standard deviation and percentage of losing pens, and resulted in a reduction in the frequency of losses greater than 20 dollars per head compared to cash marketing. Losses over 40 dollars per head still occurred, however, with this strategy.

These results indicate that waiting for a non-inverted window to appear can be risky. In several cases the producer was forced to sell production on the cash market. Many times, the feed cost and cash price combinations resulted in large losses, and some form of price protection was needed. Decreasing the window floor to 0.05 dollars per pound liveweight under the projected break-even price resulted in more non-inverted windows being taken by the producer and an improvement in the selective strategies, but a sacrifice in mean returns was made and large losses over 40 dollars per head were not eliminated. Decreasing the window floor to 0.10 dollars per pound liveweight below the projected break-even price resulted in protection occurring at a price that was lower than needed.

Purchasing a minimum price contract at farrowing instead of waiting for a window to appear paid off. The price of the option was more than offset by the return from holding insurance that guaranteed the producer the projected break-even price. One can conclude from these results that the routine BE/MPC strategies were superior to the selective break-even window contracting strategies because the producer was never forced to sell on the cash market.

6.4 Chapter Summary

Chapter 6 examined several types of window contracting strategies, some of the strategies incorporating a minimum price contracting strategy when the window was inverted, and two routine minimum price contracting strategies from 1981 to 1995. The routine 50% window (NS) , BE/MPC (NS) and MPC strategies worked well in reducing the standard deviation of returns and number of large losses incurred by the producer compared to cash marketing. These strategies did require a small sacrifice in terms of lower mean revenues than cash marketing to achieve the downside protection. The mean of returns and frequency of losses greater than 20 dollars per head with the BE/MPC (NS) and MPC strategies were superior to those with the routine 50% window (NS) strategy. The standard deviation of returns was superior, though, with the routine 50% window (NS) strategy. Although these strategies resulted in lower mean returns than cash marketing, due to the cost of purchasing the minimum price contracts (BE/MPC (NS) and MPC strategies) and/or limited upside potential (BE/MPC (NS) and 50% window (NS) strategies), the additional downside protection was worth the sacrifice in return potential. The selective window contracting strategies did result in a smaller sacrifice in mean revenues and decreased the standard deviation of returns and percentage of losing pens, but they left the producer exposed to the cash market in many critical time periods when price protection was needed.

Sharing gains and losses resulted in a slightly higher mean and lower standard deviation of returns than not sharing, but it did not reduce the frequency of large losses as well as not sharing. Locking in or not locking in feed costs resulted in very slight changes in the distributions of returns, probably due to the fact that the projected costs seemed to forecast the actual costs at sale time accurately (Figure 19). Although costs did not need to be locked in to result in a window contracting strategy that effectively reduced large losses without greatly affecting mean returns compared to cash marketing, these cost forecasts do need to be known in order to determine whether a contract offers a floor price that will likely cover actual production costs.

7. Case Study of Select Marketing Strategies from 1990 to 1995

Although one marketing strategy may appear to be superior to another when examined over a fixed length in time, one must remember that the effectiveness of these strategies are subject to the time period examined.

Since 1989, Alberta has formula priced hogs based primarily on U.S. cash prices. (section 2.3). This may have changed the effectiveness of one or more of the marketing strategies examined in this study, due to a potential increase in the correlation between U.S.-based futures markets and Alberta hog prices and more stable cash marketing returns from 1989 to 1995 (Figure 8). It was hypothesized that the various strategies would have a different effect in reducing risk during more recent times. This chapter briefly outlines the effectiveness of select marketing strategies from 1990 to 1995. The returns from select marketing strategies from 1990 to 1995 are shown in Table 10.

Table 10. Comparison of Real Net Revenues - Dollars per Head (1990-1995)

Strategy	Mean	Standard Deviation	Maximum Loss	Maximum Profit	< -20 $/head	< -40 $/head	% Losing Pens
Cash Marketing (1981-1995)	19.72	32.94	46.98	116.86	54	7	25.7
Cash Marketing	8.85	16.89	35.48	53.24	17	0	26.5
Routine Hedging	4.01	15.70	38.99	49.18	26	0	37.4
5-10-15 Selective Hedge	10.28	18.13	35.48	55.32	17	0	26.2
10-10-15 Selective Hedge	**10.62**	18.43	35.48	55.32	17	0	26.5
Routine Forward Contracting	1.39	15.04	31.56	45.21	22	0	47.3
Routine MPC	3.71	13.76	27.80	38.54	9	0	40.6
Routine 50% Window (NS)	5.26	**13.23**	**24.47**	**31.71**	6	0	37.1
Routine BE/MPC (NS)	3.70	13.69	27.80	38.54	9	0	40.6
Selective BE Window (NS)	7.30	14.78	35.48	53.24	17	0	25.9

The cash marketing returns changed quite drastically using data from 1990 to 1995. The mean of net revenue decreased by over 10 dollars per head and the standard deviation decreased by over 16 dollars per head over the last five years. Elimination of the large profits of 1982, 1983, 1987 and 1988 when hog prices were very high (Figure 10) and feed prices were very low (Figure 11), and large losses of 1988, 1989 (Figure 8) was responsible for these changes. The maximum loss and gain figures decreased using the more recent data, which is a also a reflection of the increase in market stability.

It is evident from these figures that the routine 50% window (NS) contracting strategy worked best in terms of reducing risk to the producer. This strategy lowered mean returns by approximately 3 dollars per head compared to the cash marketing results, but the standard deviation of returns, maximum loss and frequency of losses greater than 20 and 40 dollars per head were also reduced. These samples of real net revenues from 1990 to 1995 indicate that the 50% window (NS) contracts are much more effective in reducing losses than the other strategies, and that the routine BE/MPC (NS) window contracting strategies and routine MPC strategies were more expensive over this time period. In the case of the BE/MPC (NS) window contracting strategy, the producer purchased many minimum price contracts over that time period and the price of these contracts were quite expensive (Figures 31 and 32). The routine MPC contracting strategy was correspondingly very expensive as well.

A large change in the effectiveness of routine forward contracting is also evident. The mean return from forward contracting is very low and the frequency of large losses is the largest among all groups examined, indicating that over the last five years this strategy would have been very ineffective.

The selective hedging strategies again increased the mean of net revenues compared to cash marketing; similar to the results of the 1981 to 1995 simulation. However, over the period 1990 to 1995, these strategies increased the standard deviation of returns with no reduction in losses greater than 20 dollars per head, indicating they were not risk reducing. The routine hedging strategy also performed poorly over this time period, with an increase in the frequency of losses greater than 20 dollars per head and the maximum loss and a large reduction in mean returns.

It must be reinforced that the effectiveness of any one marketing strategy is subject to the time period examined. Market relationships during one subsection of time may be quite different from the relationships during another, which could greatly change the effectiveness of a particular strategy. It would appear that in recent times, routinely taking a no sharing window contract developed using a 50% confidence interval to set the floor price would have provided the producer with the best combination of price protection and mean return level. This is because this strategy costs nothing to the producer up front and does provide price protection when the market price falls below the window floor. Although this strategy does not guarantee the producer a projected break-even price, in many cases such a guarantee would have been too expensive relative to its payoff.

It should also be stressed that production flowed continuously over all simulations. Producers who do have the option of producing or not producing pigs may have investment alternatives, other than producing pigs, available to them. Novak and Viney (1995) found that, from 1987 to 1993, not feeding cattle and purchasing treasury bills, which provide a guaranteed return on investment, increased the profitability of the operation, reduced risk and resulted in fewer large losses. As a result it may sometimes be an optimal marketing strategy to not have any production to market. The problem often faced by farrow to finish hog producers is that they do not have the option of ceasing production in times when financial markets look more profitable than producing pigs.

8. Discussion of Results for Alternative Risk Measures

In sections 4.1.4 and 4.1.5, E-V and CML analysis were presented as two methods of comparing risk and return tradeoffs between various marketing strategies. Simulation results in previous sections implicitly used E-V analysis when comparing the mean and standard deviations of real net revenues to determine a strategy's risk-reducing effectiveness. Safety-first criteria such as frequency of losses greater than 20 and 40 dollars per head were also incorporated into these evaluations.

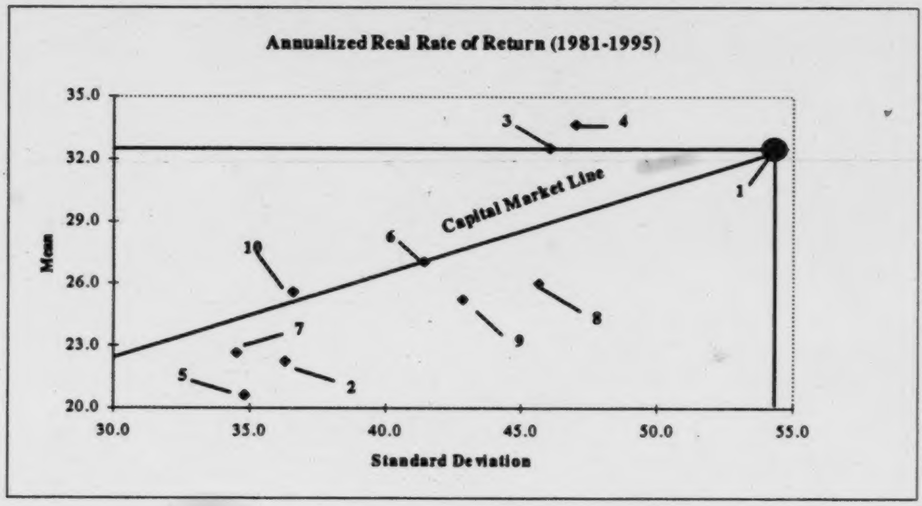
This chapter further evaluates the risk-and return trade-off of the marketing strategies simulated in this study using E-V and CML analysis. Instead of using the mean and standard deviation of real net revenues, the mean and standard deviation of the annualized real rate of return (Equation 34) are used so that a comparison can be made to financial markets.

Figure 37 illustrates a comparison of percent returns realized from the different marketing strategies simulated in this study. The capital market line demonstrates the risk and return tradeoff of the various marketing strategies compared to the risk and return tradeoff present in financial markets. The CML slope of 0.4 represents the risk and return tradeoff between 90-day treasury bills and the TSE 300 market index. All points above this line provide a greater level of return per level of standard deviation to the financial market and thus will be preferred by risk averse investors over investment in financial markets. Only the selective break-even routine window strategy and the two selective hedging strategies are located above the CML. Therefore using the selective hedging or selective break-even window marketing strategies analyzed in this study may be a desirable alternative to cash marketing using a risk-return tradeoff common to financial markets. All other strategies would not be preferred by these criteria.

The horizontal and vertical lines provide references for E-V analysis. Marketing strategies lying below and to the left of cash marketing and above and to the right of cash marketing neither dominate nor are dominated by cash marketing. Strategies above and to the left of cash marketing dominate the cash marketing strategy. Cash marketing dominates marketing strategies below and to the right of cash marketing.

No marketing strategies were dominated by cash marketing in this study. Only the 5-10-15 and 10-10-15 selective hedges dominated cash marketing. Several of the marketing strategies simulated were neither dominated by or dominant over cash marketing.

Figure 37. E-V Analysis of Select Marketing Strategies



where:

1. Cash marketing
2. Routine Hedging
3. 5-10-15 Selective Hedge
4. 10-10-15 Selective Hedge
5 Routine Forward Contracting
6. Routine 50% Window (S)
7. Routine 50% Window (NS)
8. Routine BE/MPC (S)
9. Routine BE/MPC (NS)
10. Selective BE Window (NS)

9. Summary of Results and Conclusions

9.1 Results

This study simulated and evaluated several different types of marketing strategies from 1981 to 1995 and 1990 to 1995. The various types of strategies analyzed included cash marketing, routine and selective hedging, routine forward contracting, routine window contracting using either a confidence interval or a projected break-even cost to set the window floor (the latter included periodically purchasing a minimum price contract when the offered window was inverted), routine minimum price contracting and selective window contracting. All of the window strategies were simulated under two difference agreements; a 50/50 sharing agreement and a no sharing agreement. The break-even window and minimum price contracting strategies were simulated with all costs locked in at farrowing by forward purchasing inputs, or leaving costs exposed to the cash market.

No one marketing strategy stood out as superior in all measurement criteria; increased mean revenues, lowered the standard deviation of revenues, reduced the frequency of large losses and reduced the maximum loss in absolute value. There are two main reasons why this was so. In several circumstances, such as the periods of late 1988, early 1989, late 1994 and early 1995 feed prices sharply increased while hog prices sharply declined. Some marketing strategies allowed for the hog price to be somewhat controlled, but did not provide protection on the input side, that is feed prices. Other strategies that used window contracting or minimum price contracting did allow for the eventual price received to cover the projected break-even price, but were expensive in doing so due to the cost of price insurance.

Routinely or selectively hedging production do not appear to be viable marketing strategies to producers concerned with experiencing large losses, although both selective hedging strategies resulted in higher mean net revenues over cash marketing (Table 4). The period of losses in 1992 were reduced with routine hedging because feed prices were not at a level that severely reduced profitability. Routinely hedging production, however, resulted in some basis risk and large losses in earlier years, as well as large potential margin calls in some periods. Selective hedging did slightly increase mean revenues and decrease the standard deviation of revenues but did not reduce the maximum loss or frequency of large losses compared to cash marketing, due to hogs being left unhedged during critical time periods and basis risk on some hedges.

Routine forward contracting eliminated basis risk and reduced some of the large losses observed from the selective hedging and selective window contracting strategies, but mean returns were also reduced. This could potentially be due to a risk premium existing in deferred live hog futures contracts, which lowered the price received compared to a situation where no risk premium existed. Once again high feed prices during certain time periods reduced the profitability of such a marketing program.

Window contracts developed using confidence intervals eliminated basis risk to the producer but provided mixed results depending on the type of window simulated. All window contracting strategies resulted in a lower mean and standard deviation of returns compared to cash marketing. Contracts using a 75% confidence interval to set the floor price were often too wide, and as a result did not provide adequate downside protection. Contracts using a 25% confidence interval and no sharing were often too narrow and limited upside potential to the extent that the producer incurred losses that were not incurred with the no share 50% window strategy. Contracts using a 50% confidence interval to establish the floor price seemed to provide the most acceptable balance between downside protection and ability to gain from upward market moves.

Sharing gains and losses 50/50 outside of the window, compared to not sharing gains and losses, had the effect of slightly increasing mean returns while sacrificing some downside protection. This was because a sharing agreement allows for producers to partially take advantage of prices higher than the window ceiling price in return for only partial protection from prices lower than the ceiling floor. Whether or not a producer prefers a no share agreement versus a sharing agreement would thus depend on the relative importance of the ability to gain from upward market moves versus having a fixed floor price. A sharing agreement results in the producer taking on more price risk in exchange for greater upside potential, while a no share agreement results in less price risk to the producer in exchange for less upside potential.

Routinely taking a 50% no sharing window contract had the best risk and return tradeoff compared to the other window contracts established using confidence intervals, routine hedging, selective hedging and cash marketing. This strategy reduced the frequency of losses over 20 dollars per head, eliminated losses over 40 dollars per head, and effectively decreased the standard deviation of returns. A mean return of over 15 dollars per head was realized with this strategy which, while lower than the average return from cash marketing, was still profitable. Although the 50% no share window strategy did limit upside potential, the windows were wide enough to provide the producer with some degree of price flexibility while yielding effective downside market protection. As a result, the routine 50% no share window contracting strategy is a viable alternative to cash marketing. One weakness of this strategy, however, is that the window floor price will not necessarily cover the projected break-even price. A combination of extremely high feed prices and a low hog price may result in a final price that does not cover costs. However, the benefit of these window contracts is that the floor price will minimize losses during such cases.

The routine BE/MPC strategies that established a floor price equal to the projected break-even price worked well in reducing risk to the producer by eliminating a number of the large losses experienced with some of the other marketing strategies. All of these strategies eliminated any basis risk to the producer. Reducing the floor below the projected break-even price (BE-0.03/MPC, BE-0.05/MPC, BE-0.10/MPC) reduced the effectiveness of these windows in controlling the number of large losses experienced by the producer because price protection occurred at a level that was too low. Sharing in gains or losses slightly increased the frequency of these losses compared to not sharing gains or losses, due to limited downside protection. The effect of sharing versus not sharing was small though, because the floor price was set at a level high enough to cover projected break-even costs. As a result, sharing losses with prices below the floor price still had the effect of minimizing those losses. The BE/MPC strategies did reduce mean returns compared to cash marketing, but the change was minimal.

None of the BE/MPC strategies performed poorly from 1981 to 1995, regardless of whether they shared or did not share gains and losses, and whether costs were locked in or not. They all reduced the standard deviation of returns and truncated the lower end of the revenue distribution. The effectiveness of the BE/MPC strategies were due to their ability to provide the producer with a minimum price that guaranteed covering the projected total cost at sale time. During periods when the projected break-even price was high and the Canadianized futures price was low, the window contracts were inverted and the producer instead had to purchase a minimum price contract. These contracts required a premium and were often very expensive because they guaranteed a price much higher than the forecasted price at sale time. Purchasing the premiums did pay off compared to being exposed to the cash market during many of the periods during the 1980's, and did not pay off from 1990 to 1995 (Table 10).

Locking in all costs at farrowing by forward purchasing enough inputs to raise the pen to finishing did not provide much benefit to the producer. In some cases, locking in all costs resulted in a slightly higher frequency of losses greater than 20 dollars per head due to decreases in feed costs from farrow to finish. Therefore the advantage of locking in all costs is negligible, although projected break-even costs should still be known by the producer to effectively evaluate current market conditions and the potential benefit of the contract being offered.

The minimum price contracting strategy worked well in controlling the frequency of large losses, while not limiting the upside price potential. These strategies also eliminated any basis risk to the producer. It should be noted that in many cases the price of purchasing a minimum price contract could reach as high as 40 dollars per head, becoming extremely expensive price insurance. In the majority of cases, purchasing this insurance paid off although in others it did not. This is especially true during the period of 1990 to 1995, during which time the option premiums were very expensive and did not pay off (Table 10).

Selective window contracting, with the floor price set at the projected break-even price, attempts to eliminate expensive price insurance by not buying minimum price contracts and instead waiting for a non-inverted window to appear. These strategies did not effectively reduce a number of the large losses experienced with other marketing strategies. This is because in several critical time periods all of the price windows were inverted, resulting in hogs being sold on a depressed cash market. As a result, the producer is probably just as well off to incorporate a selective hedging strategy as to use a selective window contracting strategy. Selective hedging was shown to increase mean returns compared to cash marketing, while selective window contracting reduced mean returns.

9.2 Conclusions

Fluctuating hog and feed prices in Alberta pose a serious marketing challenge to producers. Simulations show that cash marketing returns were highly variable from 1981 to

1995, with many periods of large losses over that time. The routine 50% window contracting strategy, with no sharing of gains or losses, can be used by hog producers to eliminate some of this price risk. This strategy was shown to eliminate many of the large losses seen with cash marketing and decreased the variability of returns with a slight sacrifice being made in terms of average returns. The BE/MPC (NS) and MPC strategies were superior to the 50% window (NS) strategy from 1981 to 1995, but were outperformed by the 50% window (NS) strategy from 1990 to 1995. This was due to the high cost of the minimum price contracts guaranteeing a projected break-even price paying off over the longer time period but not paying off from 1990 to 1995. As a result, this study indicates that routinely taking a window contract using a 50% confidence interval to set the floor price, and not sharing gains or losses outside of the window, is optimal in terms of reducing risk to the producer.

One limitation of this study is that, although short term window contracts are currently available to Manitoba hog producers, they are not available to Alberta producers. However, this study provides a framework in which to develop short term window contracts that are fair to both the contract provider and producer. Recent changes now allow Alberta producers to sell hogs directly to buyers, which gives producers the opportunity to negotiate new derivative instruments with these buyers. It may be the case that Alberta will follow Manitoba's lead in the accessibility of window contracts to Alberta producers.

Another limitation of this study is that production risk was not incorporated into the simulated hog farm. Certain farms may have significant production risk, lowering their abilities to meet window contract specifications. This may drastically change the effectiveness of the window contracting strategies. Therefore producers should carefully consider their production consistency and risk before incorporating such a strategy.

Further research should include:

1. Develop long term window contracts such as those being offered in the U.S., and examine their risk-reducing effectiveness to hog producers and buyers.
2. Examine risk reducing effectiveness of short term window contracts to hog buyers.
3. Investigate risk reducing effectiveness of producers buying puts and selling calls on the CME, thereby creating their own window contracts (although exposing themselves to basis and exchange rate risk with such a strategy).
4. The live hog futures contract was recently changed to the lean hog futures contract, which is traded according to a dressed hog price. This may change basis behavior and volatility estimates of the futures contracts and could alter the width, and thus effectiveness, of window contracts developed using the methodology in this study. The historical live hog futures data could be altered to reflect a dressed price, which could then be used as a proxy for lean hog futures data. The altered live hog futures data would allow for window contracts to be developed and examined based on lean hog futures prices.

10. Bibliography

Adam, B., P. Garcia, and R. J. Hauser. 1993. Robust Live Hog Pricing Strategies Under Uncertain Prices and Risk Preferences. *The Journal of Futures Markets.* 13(8):849-864.

Aherne, F. 1996. Personal Communication. 11634-77 Avenue. Edmonton, Alberta. T6G 0M3.

Alberta Agriculture. 1992. *Pork Production Course.* Prepared by the Animal Industry Division, Field Services Sector and Home Study Program.

Alberta Agriculture. Revised September, 1995. *Alberta Pork Production Handbook.* Alberta Agriculture Pork Industry Branch. Agdex 440/00-1.

Alberta Agriculture. 1988-1994. *Alberta's Agricultural Exports.* Alberta Agriculture, Food and Rural Development. Market Analysis and Statistics Branch.

Alberta Agriculture. Revised September, 1995. *Alberta's Pork Production Industry.* Alberta Agriculture, Food and Rural Development. Pork Industry Branch. Agdex 440/00-1.

Alberta Pork Producers Development Corporation. March, 1996. *Forward Price Contracting Program.* Pamphlet.

Bauer, L. April, 1988. *Risk in Agriculture and Its Management.* University of Alberta.

Benson, B., M. Faminow, M. Marquis and D. Sauer. 1994. Intra-National Effects of a Countervailing Duty on the United States/Canadian Hog Market. *Review of Agricultural Economics.* 16:187-201.

Black, F. 1976. The Pricing of Commodity Contracts. *Journal of Financial Economics.* 3:167-179.

Black, F. and M. Scholes. 1973. The Pricing of Options and Corporate Liabilities. *Journal of Political Economy.* 81(May-June):637-739.

Brandt, J. 1985. Forecasting and Hedging: An Illustration of Risk Reduction in the Hog Industry. *American Journal of Agricultural Economics.* 67(2):24-32.

Brealey, R., S. Myers, G. Sick, and R. Giammarino. 1992. *Principles of Corporate Finance.* Second Canadian Edition. McGraw-Hill Ryerson Limited. Toronto.

Collins, R. 1985. Expected Utility, Debt-Equity Structure, and Risk Balancing. *American Journal of Agricultural Economics.* 67:627-629.

Das, S. 1994. *Swap and Derivative Financing.* Irwin Professional Publishing. New York, New York.

Dial, G. and R. Morrison. 1996. *Factors Driving Expansion in the U.S.A..* Proceedings of the 1996 Banff Pork Seminar. Advances in Pork Production. Department of Agricultural, Food and Nutritional Science. University of Alberta. 7:73-83.

DiPietre, D. 1996. *Current U.S. Marketing Issues and Packer Contracts.* Alberta Pork Congress, 1996 Proceedings. June 11-13. Edited by Marvin Salomon and Irene Wenger. Alberta Agriculture, Food and Rural Development.

Ditsch, M. and R. Leuthold. 1996. *Evaluating the Hedging Potential of the Lean Hog Futures* Contract. NCR-134 Conference. Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, Illinois. April 22-23.

Fleisher, B. 1990. *Agricultural Risk Management.* Lynne Rienner Publishers, Inc.. Boulder, Colorado.

Fletcher's Fine Foods Ltd. 1996. Red Deer, Alberta.

Gore, P., and R. Leuthold. 1993. *Selective Hedging Opportunities and Strategies in Livestock Futures and Options Markets.* OFOR Paper Number 93-01. July.

Gordon, J. 1985. *The Distribution of Daily Changes in Commodity Futures Prices.* Technical Bulletin No. 1702. Economic Research Service, USDA.

Gowans, J. 1996. Gowans Feed Consulting. Personal Communication. R.R.2. Red Deer, Alberta. T4N 5E2

Hayenga, M. , D. DiPietre, J. Skadberg, and T. Schroeder. 1984. Profitable Hedging Opportunities and Risk Premiums for Producers in Live Cattle and Live Hog Futures Markets. *The Journal of Futures Markets.* 4(2):141-154.

Hayes, D. and A. Schmitz. 1986. *Hog Cycles and Countercyclical Production Response.* MERC Staff Report No. 4-86. Meat Export Research Center Report. Department of Economics. Iowa State University. Ames, Iowa. 50011. October.

Higgison. N. 1987. *North American Hog Price Relationships.* M.Sc. Thesis. Department of Rural Economy. Faculty of Agriculture and Forestry. University of Alberta. November.

Holt, M., J. Brandt, and C. Hurt. 1985. Managing Risk With Forecasts and the Futures Market: An Application to Hog Production. *Journal of the American Society of Farm Managers and Rural Appraisers.* 49(1):6-11.

Hull, J. 1995. *Introduction to Futures and Options Markets.* Second Edition. New Jersey, Prentice Hall Inc..

Hull, J. 1993. *Options, Futures and Other Derivative Securities.* Second Edition. New Jersey, Prentice Hall Inc..

Johnson, C. and K. Foster. 1994. Risk Preferences and Contracting in the U.S. Hog Industry. *Journal of Agricultural and Applied Economics.* 26(2):393-405. December.

Kenyon, D. and J. Clay. 1987. Analysis of Profit Margin Hedging Strategies for Hog Producers. *The Journal of Futures Markets.* 7(2):183-202

Keynes, J. M. 1930. *A Treatise on Money, II.* MacMillan and Co., London. pp 142-147.

Koontz, S., M. Hudson, and M. Hughes. 1992. Livestock Futures Markets and Rational Price Formation: Evidence for Live Cattle and Live Hogs. *Southern Journal of Agricultural Economics.* Southern Agricultural Economics Association. 24(1):233-249. July.

Lawrence, J. 1995. *Long-Term Hog Marketing Agreements.* Iowa State University. University Extension. Ames , Iowa. M1282lMarch

Lawrence, J. and M. Kaylen. *Risk Management for Livestock Producers: Hedging and Contract Production.* Staff Paper No. P90-49. Department of Agricultural and Applied Economics. University of Minnesota. Institute of Agriculture, Forestry and Home Economics. St. Paul, Minnesota. 55108.

Leuthold, R. and P. Hartmann. 1979. A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market. *American Journal of Agricultural Economics.* 61:482-489.

Leuthold, R. and R. Mokler. 1980. *Feeding-Margin Hedging in the Cattle Industry.* International Futures Trading Seminar Proceeding. Chicago Board of Trade of the City of Chicago. 6:56-67.

Martin, L. and P. Garcia. 1981. The Price-Forecasting Performance of Futures Markets for Live Cattle and Hogs: A Dissagregated Analysis. *American Journal of Agricultural Economics.* 63:209-215.

Meilke, K. and G. Moschini. 1992. *A Chronicle of Canadian Hog Stabilization Programs and U.S. Countervailing Duties on Hogs and Pork.* GATT Research Paper 91-Gatt 5. Center for Agricultural and Rural Development. Iowa State University. Ames, Iowa. 50011-1070. April.

Meilke, K. and M. Scally. 1988. *Trade in Vertically Related Markets: the Case of Hogs and Pork.* University of Guelph. Department of Agricultural Economics and Business. Working Paper WP88 / 17. November.

Morrison, R. and W. Lazarus. 1996. *The Economics of Production Contracting.* Proceedings of the 1996 Banff Pork Seminar. Advances in Pork Production. Department of Agricultural, Food and Nutritional Science. University of Alberta. 7:67-71.

Munro, E. 1993. *Retained Ownership of Beef Calves in Alberta.* M.Sc. Thesis. Department of Rural Economy. Faculty of Agriculture and Forestry. University of Alberta. August.

Novak, F., L. Bauer, S. Dailly, and R. Melvin. 1992. *An Analysis of Risk and Return in Hog Feeding.* Project Report No. 92-09. Farming for the Future Project No. 90-0713. Department of Rural Economy. Faculty of Agriculture and Forestry. University of Alberta. December, 1992.

Novak, F., and J. Unterschultz. 1996. Simple Risk Measures When Hedging Commodities Using Foreign Markets: A Note. *The Journal of Futures Markets.* 16(2):211-217.

Novak, F. and B. Viney. 1995. *Alternative Pricing and Delivery Strategies for Alberta Cattle Feeders.* Project Report No. 95-06. Alberta Agricultural Research Institute Project No. 940490. Department of Rural Economy. Faculty of Agriculture and Forestry. University of Alberta. August.

Perkins, B. 1996. Perkins Farms. Personal Communication. Box 2939. Wainwright, Alberta. T9W 1S8

Purcell, W. 1991. *Agricultural Futures and Options: Principles and Strategies.* Macmillan Publishing Company. New York.

Rhodes, V. 1990. *Structural Trends in U.S. Hog Production.* University of Missouri. Agricultural Economics Report 1990-5. Columbia, Missouri. 652111.

Robison, L., P. Barry, J. Kliebenstein, and G. Patrick. 1984. *Risk Management in Agriculture*. Chapter 2. Edited by Peter J. Barry. Iowa State University Press. Ames, Iowa.

Ross, S., R. Westerfield, B. Jordan, and G. Roberts. 1993. *Fundamentals of Corporate Finance.* First Canadian Edition. Richard D. Irwin Inc.. Homewood, Illinois.

Salomons, M., B. Dening, and C. Darroch. 1996. *Effects of Taking Pigs to Heavier Weights on Average Daily Gain, Feed Conversion, and Backfat.* Proceedings of the 1996 Banff Pork Seminar. Advances in Pork Production. Department of Agricultural, Food and Nutritional Science. University of Alberta. 7:67-71.

Saskatchewan Pork Implementation Team. 1995. *PorkPlan: Pork Production Cost and Financial Model, Version 1.0d.*

Shaw, G. 1996. Norcombe Holdings. Personal Communication. Box 5004. Lacombe, Alberta. T4L 1W7.

Sparks Companies, Inc.. 1995. Design of a Minimum Contract for SPI Marketing Group. Suite 130, 106 Colonnade Road, Nepean, Ontario. K2W 7L6. March 31.

Statistics Canada. 1993. *Census Overview of Canadian Agriculture: 1971-1991.* Cat. 93-48.

Tan, M. 1988. *The National Tripartite Stabilization Program for Red Meats: Hog Model.* Working Paper 5/88. Market Outlook and Policy Division. Policy Branch. Agriculture Canada. June.

Toma, W. 1996. Alberta Pork Producers Development Corporation. Personal Communication.

Tomek, W. 1987. *Effects of Futures and Options Trading on Farm Incomes.* Cornell Agricultural Economics Staff Paper, No. 87-9. Department of Agricultural Economics. Cornell University Agricultural Experiment Station. New York State College of Agriculture and Life Sciences. Cornell University, Ithaca, New York, 14853. May.

Turvey, C. and H. Driver. 1987. Systematic and Nonsystematic Risks in Agriculture. *Canadian Journal of Agricultural Economics.* 35:387-401.

U.S. Department of Agriculture. 1995. *FBEI updates: Structural Change. Updates on Farm Business Economic Indicators. Structural Change in U.S. Hog Production between 1978 and 1992.* Economic Research Service. October.

Unterschultz, J. 1991. *Risk in Cattle Finishing in Alberta.* M.Sc. Thesis. Department of Rural Economy. Faculty of Agriculture and Forestry. University of Alberta. July.

Unterschultz, J. 1996. Graduate Advisor and Examiner. Personal Communication. 529 G.S.B. University of Alberta. Edmonton, Alberta. T6G 2E1.

Von Neumann, J., and O. Morgenstern. 1947. *Theory of Games and Economic Behavior*. Princeton. Princeton University Press.

Wei, J. 1994. *Pricing Forward Contracts and Options of Foreign Assets*. Contributed article to the 2nd edition of Handbook of Derivative Instruments. Department of Management Science. College of Commerce. University of Saskatchewan.

Young, D. 1984. *Risk Management in Agriculture*. Chapter 3. Edited by Peter J. Barry. Iowa State University Press. Ames, Iowa.

Appendix A. Simulation Methodology

The following section provides the parameters and methodology used to simulate weekly production, costs and revenues for a 350 sow farrow to finish hog operation. Hogs required 25 weeks (175 days) to reach market weight. All real figures were calculated in 1995 dollars.

Cost and Revenue Calculations

Total Costs (*Totcost*) per Pen:
$Totcost_{t+25} = Totvar_{t+25} + Fixcost_{t+25}$

Net Revenue (*Netrev*) per Pen:
$Netrev_{t+25} = Totrev_{t+25} - Totcost_{t+25}$

Real Net Revenue (*Realnetrev*) per Pen:
$Realnetrev_{t+25} = Netrev_{t+25} / cpi_{t+25}$

Production Parameters

Table 11. Breeding Stock Replacement Rates and Pig Death Losses.

	Sows (%)	Boars (%)	Pre-weaned Pigs (%)	Starter Pigs (%)	Grower Pigs (%)
Replacement Rate	47	50	-	-	-
Death Loss	-	-	10	1.5	1

Table 12. Feeder Pig Feeding Program by Category of Pig

	Category				
	Starter 1	**Starter 2**	**Grower**	**Finisher 1**	**Finisher 2**
Weight Range (kg)	7-15	15-20	20-50	50-70	70-107
Weeks in Weight Range	4	2	7	3	6
Daily Rate of Gain (kg)	0.286	0.357	0.612	0.952	0.881
Feed Conversion (kg Feed:1kg Gain)	1.72	2.07	2.76	3.62	4.08

Finished pig grading (*grading*)=1.07
Finished pig dressing % (*findress*)=80
Finished pig liveweight (*outwt*)=107 kg
Sow cull liveweight (*sowcullwt*)=200 kg
Boar cull liveweight (*boarcullwt*)=225 kg
Sow dressing % (*sowdress*)=78
Boar dressing % (*boardress*)=78

Breeding Stock Weekly Feed Consumption:
Dry sows and replacement sows (_dryintake_)=_2.35 kg/day*7_
Lactating sows (_wetintake_)=_6.11 kg/day*7_
Boars (_boarintake_)=_2.35 kg/day*7_

Weekly Production
Number of total sows (_ntotsows_)=350
Farrowings per sow per year (_faryr_)=2.23
Farrowing per week (_farwk_)=_ntotsows*faryr/52_
Sow to boar ratio (_sowtoboar_)=35:1
Number of boars (_totboars_)=_ntotsows/sowtoboar_
Number of pigs born alive per litter (_littersize_)=10
Number of pigs born alive per week (_pborna_)=_farwk*littersize_
Number of starter 1 pigs (_ns1_)=_0.9*pborna_
Number of starter 2 pigs (_ns2_)=_0.985*ns1_
Number of grower pigs (_ngrowers_)=_0.99*ns2_
Number of finisher 1 pigs (_nf1_)=_ngrowers_
Number of finisher 2 pigs (_nf2_)=_ngrowers_
Number of finished pigs marketed (_nmktpigs_)=_ngrowers_
Number of dry sows per pen (_ndrysows_)=_farwk_
Number of lactating sows per pen (_nwetsows_)=_farwk_
Number of boars per pen (_nboars_)=_farwk/sowtoboar_
Number of culled boars per week (_boarculls_)=_ntotsows/sowtoboar*boarrep/52_
Number of culled sows per week (_sowculls_)=_(ntotsows*sowrep)/52_
Number of purchased boars per week (_boarpur_)= _boarculls_
Number of purchased sows per week (_sowpur_)= _sowculls_

Prices
Alberta index 100 finished hog price (_Abind100_)=$/kg dressed
Sow cull price (_sowcullpr_)=_Abind100*62%_
Boar cull price (_boarcullpr_)=_sowcullpr*83%_
Replacement boar price (_repboarpr_)=_(Abind100* outwt *findress*grading)*4_
Replacement sow price (_repsowpr_)= _(Abind100* outwt *findress*grading)*2.2_

Weekly Revenues

Finished hog revenue (_Finpigrev_)=_nmktpigs*Abind100* outwt *findress*grading_

Culled boar revenue (_Culboarrev_)=_boarculls*boarcullwt *boardress *boarcullpr_

Culled sow revenue (_Culsowrev_)=_sowculls*sowcullwt*sowdress*sowcullpr_

Weekly Costs

Table 13. Weekly Prices and Costs

Input	Adjusted by:	1995 Price Level
Barley *(barleypr)*	weekly time series	Red Deer Street Price ($/tonne)
Wheat *(wheatpr)*	weekly time series	Red Deer Street Price ($/tonne)
Canola Meal *(canmeal)*	weekly time series	Vancouver Price ($/tonne)
Canola Oil *(canoil)*	weekly time series	F.O.B. Plants ($/tonne)
Soybean Meal (*soymeal*)	weekly time series	Vancouver Price ($/tonne)
Starter Supplement *(startsup)*	PF index	1,200 $/tonne
Feeder Supplement *(feedsup)*	PF index	900 $/tonne
Sow and Boar Supplement *(sowsup)*	PF index	650 $/tonne
Feed Manufacturing *(manuf)*	PF index	29 $/tonne
Veterinary Supplies & Services *(vet)*	Vet index	2.00 $/weaned pig
Utilities *(util)*	CPI	4.50 $/pig marketed
Maintanence *(maint)*	Sup & Serv index	302.88 $/week
Manure Handling & Disposal (*manure*)	Sup & Serv index	211.31 $/week
Artificial Insemination *(breed)*	AI index	102.88/week
Marketing Fee *(market)*	Sup & Serv index	1.25 $/ pig marketed
Rental Cost *(rental)*	CPI	9.61 $/week
Trucking *(truck)*	Sup & Serv	1.50 $/ pig marketed
Office & Accounting *(offact)*	CPI	51.92 $/week
Labor & $12.35/hour *(labor)*	Labor index	1,168.50 $/week
Salary to Owner *(salary)*	Labor index	865.38 $/week
Taxes and Insurance *(taxins)*	CPI	232.52 $/week
Depreciation *(deprec)*	none	2,371.77 $/week
Land Payments *(land)*	none	135.53 $/week

Note: Some of the above costs required several steps in calculation. Below are the steps for calculating those costs.

Maintenance on Capital:
Capital required per sow per year (*capisow*)=$3 000
Maintanence rate as a percentage of value of capital (*mainrat*)=1.5%
Weely maintanence cost =*(capisow*ntotsows *maintrat)/52*

Manure Handling and Disposal:
Manure production rate in cubic feet per sow per day (*manurate*)=2.30
Manure handling and disposal fee (*manurfee*)=$0.0060/gallon
Conversion of gallons per cubic foot (*gallons*)=6.25
Weekly manure cost= *7*(ntotsows*manurfee*manurate*gallons)*

Replacement Breeding Stock:
Replacement breeding stock cost per week=*(boarpur*repboarpr) + (sowpur*repsowpr)*

Labor:
Hours labor required per sow per year (*sowhrs*)=20
Hours of labor contributed by manager per year (*manhrs*)=2 080
Wage rate per hour (*wage*)=$12.35
Weekly labor cost=*((sowhrs*ntotsows-manhrs)*wage rate)/52*

Depreciation:
Lifetime of buildings and equipment in years (_buildlife_)=20
Salvage value of buildings and equipment at end of 20 years (_salvage_)= 0
Amortization factor for 20 years @ 10% (_amortize_)=8.5136
Weekly depreciation cost =_(capisow *ntotsows -salvage)/amortize/52_

Land Payments:
Value of land for operation (_land_)=$60 000
Weekly cost of land = _land/amortize/52_

Weekly Feed Costs

Defining:
1. _s1rog_ = starter 1 pig rate of gain (kg/day)
2. _s2rog_ = starter 2 pigs rate of gain
3. _growrog_ = grower pigs rate of gain
4. _f1rog_ = finisher 1 pigs rate of gain
5. _f2rog_ = finisher 2 pigs rate of gain
6. _s1con_ = starter 1 pigs feed conversion (kg feed: 1 kg gain)
7. _s2con_ = starter 2 pigs feed conversion
8. _growcon_ = grower pigs feed conversion
9. _f1con_ = finisher 1 pigs feed conversion
10. _f2con_ = finisher 2 pigs feed conversion

Gestating sows (_drysowfed_):=_7*ndrysows*dryintake * ((0.85*barleypr/1000) + (0.10*soymeal/1000) + (0.01*canoil/1000) + (0.04*rsowsup/1000) + (manuf/1000))_

Lactating sows (_wetsowfed_)= _7*nwetsows* wetintake* ((0.46* barleypr/1000) + (0.30*wheatpr/1000) + (0.179*soymeal /1000) + (0.015*canoil /1000) + (0.04*sowsup /1000) + (manuf/1000))_

Boars (_boarfed_)= _7*nboars*boarintake * ((0.85*barleypr/1000) + (0.10*soymeal /1000) + (0.01*canoil /1000) + (0.04*sowsup/1000) + (manuf/1000))_

Starter 1 pigs (_s1fed_)=_7*ns1*s1rog*s1con*((0.653*wheatpr/1000) + (0.174*soymeal /1000) + (0.023*canoil/1000) + (0.15*startsup/1000) + (manuf/1000))_

Starter 2 pigs (_s2fed_)=_7*ns2*s1rog*s1con*((0.653*wheatpr/1000) + (0.174*soymeal/1000) + (0.023*canoil/1000) + (0.15*startsup /1000) + (manuf/1000))_

Grower pigs (_growfed_)= _7*ngrowers*growrog*growcon*((0.059*barleypr/1000) + (0.671* wheatpr/1000) + (0.17*soymeal/1000) + (0.05*canmeal) + (0.02*canoil/1000) + (0.03*feedsup/1000) + (manuf/1000))_

Finisher 1 pigs (_f1fed_)= _7*nf1*f1rog*f1con*((0.459*barleypr/1000) + (0.339*wheatpr/1000) + (0.062*soymeal/1000) + (0.10*canmeal/1000) + (0.01*canoil) + (0.03*feedsup/1000) + (manuf/1000))_

Finisher 2 pigs ($f2fed$)= $7 * nf2 * f2rog * f2con * ((0.459 * barleypr/1000) +$
$(0.339 * wheatpr/1000) + (0.062 * soymeal/1000) + (0.10 * canmeal\ price/1000) +$
$(0.01 * canoil) + (0.03 * feedsup\ /1000) + (manuf/1000))$

Gross Revenues (*Totrev*) per Pen:
$Totrev_{t+25} = Finpigrev_{t+25} + Culboarrev_{t+25} + Culsowrev_{t+25}$

Variable Costs (*varcost*) per Pen:
Feed costs (*Feedcost*):
$Feedcost_{t+25} = \Sigma_{(t+3:t+6)}\ s1fed + \Sigma_{(t+7:t+8)}\ s2fed + \Sigma_{(t+9:t+15)}\ growfed + \Sigma_{(t+16:t+18)}\ f1fed +$
$\Sigma_{(t+19:t+24)}\ f2fed + \Sigma_{(t+16:t+18)}\ drysowfed + \Sigma_{(t+16:t+18)}\ wetsowfed + \Sigma_{(t+16:t+18)}$
$boarfed$

Other variable costs (*Othercost*):
$Othercost_{t+25} = market_{t+25} + stock_t + vet_{t+3} + (\Sigma_{(t:t+24)}\ util)/25 +$
$(\Sigma_{(t:t+24)}\ maint)/25 + (\Sigma_{(t:t+24)}\ manure)/25 + breed_t + (\Sigma_{(t:t-24)}\ rental)/25 + truck_{t+25} +$
$(\Sigma_{(t:t+24)}\ offact)/25 + (\Sigma_{(t:t+24)}\ labor)/25$

Total variable costs (*Totvar*):
$Totvar_{t+25} = Feedcost_{t+25} + Othercost_{t+25}$

Fixed Costs (*Fixcost*) per Pen:
$Fixcost_{t+25} = (\Sigma_{(t:t+24)}\ salary)/25 + (\Sigma_{(t:t+24)}\ taxins)/25 + (\Sigma_{(t:t+24)}\ deprec)/25 +$
$(\Sigma_{(t:t+24)}\ land)/25$

Table 14. Feed Rations

Starter 1 Ration (7-15 kg)	Barley	0.00%
	Wheat	65.30%
	Soybean Meal (48)	17.40%
	Canola Meal (48)	0.00%
	Canola Oil	2.30%
	Starter Supplement	15.00%
Starter 2 Ration (15-20 kg)	Barley	0.00%
	Wheat	65.30%
	Soybean Meal (48)	17.40%
	Canola Meal (48)	0.00%
	Canola Oil	2.30%
	Starter Supplement	15.00%
Grower Ration (20-50 kg)	Barley	5.90%
	Wheat	67.10%
	Soybean Meal (48)	17.00%
	Canola Meal (48)	5.00%
	Canola Oil	2.00%
	Feeder Premix (30 kg/t)	3.00%
Finisher 1 Ration (50-70 kg)	Barley	45.90%
	Wheat	33.90%
	Soybean Meal (48)	6.20%
	Canola Meal (48)	10.00%
	Canola Oil	1.00%
	Feeder Premix (30 kg/t)	3.00%
Finisher 2 Ration (70-107 kg)	Barley	45.90%
	Wheat	33.90%
	Soybean Meal (48)	6.20%
	Canola Meal (48)	10.00%
	Canola Oil	1.00%
	Feeder Premix (30 kg/t)	3.00%
Dry Sow Ration	Barley	85.00%
	Wheat	0.00%
	Soybean Meal (48)	10.00%
	Canola Meal (48)	0.00%
	Canola Oil	1.00%
	Sow Premix (40 kg/t)	4.00%
Lactating Sow Ration	Barley	46.60%
	Wheat	30.00%
	Soybean Meal (48)	17.90%
	Canola Meal (48)	0.00%
	Canola Oil	1.50%
	Sow Premix (40 kg/t)	4.00%
Boar Ration	Barley	85.00%
	Wheat	0.00%
	Soybean Meal (48)	10.00%
	Canola Meal (48)	0.00%
	Canola Oil	1.00%
	Starter Supplement	4.00%

Appendix B. Data Sources

Alberta Index 100 Hog Price

Average weekly Alberta Index 100 hog prices from 1980 to 1995 were obtained from Alberta Agriculture. The Alberta Index 100 hog price reflects the price of an index 100 hog in dollars per kilogram dressed.

Live Hog Futures Prices

Daily live hog futures prices were purchased from Tick Data Inc.. These prices were the closing futures prices for the live hog futures contracts traded on the Chicago Mercantile Exchange from 1980 to 1995. The seven live hog futures contracts traded on the CME were February, April, June, July, August, October and December live hogs.

Barley and Wheat Prices

Barley and wheat are the two major feed inputs into many Alberta hog operations. The barley and wheat prices used in this study are the Red Deer street prices for the two feedgrains measured in dollars per tonne. These prices were collected from Alberta Agriculture and are published in the *Alberta Agriculture Statistical Yearbook*. The prices are calculated from weekly surveys of Red Deer feed mills and elevator companies (Novak and Viney 1995).

Following the methodology of Novak and Viney (1995), net barley and wheat prices to producers after CBOP payments were calculated as:

$$NetBarley_t = GrBarley_t - CBOP_t$$

and

$$NetWheat_t = GrWheat_t - CBOP_t$$

where: $NetBarley_t$ = the net barley price paid by hog producers at time t
$NetWheat_t$ = the net wheat price paid by hog producers at time t
$GrBarley_t$ = the gross barley price prior to CBOP payments at time t
$GrWheat_t$ = the gross wheat price prior to CBOP payments at time t

Feed Processing

A processing fee of $29 per tonne was assessed to all feeds. This fee approximated the costs of mixing and formulating the various rations for the operation. The charge was then indexed to the first period of the study with the processed feed index. (CANSIM) This fee was reported as a typical feed processing cost by the "PorkPlan: Pork Production Cost and Financial Model, Version 1.0d."

Feed Supplements

Starter supplement, feeder supplement and sow supplement prices were collected from Gowans Feed Consulting. These prices were $925, $1200, $900 and $650 per tonne, respectively. These feed prices were also indexed back to the original period of the study using the processed feed index (CANSIM).

Canola Meal and Soybean Meal

Weekly canola meal and soybean meal prices at Vancouver from 1980 to 1995 were collected from Alberta Agriculture. These prices were reported in units of dollars per tonne. Missing data points in the price series were interpolated.

Canola Oil

Monthly canola oil prices from 1983 to 1995 were collected from the Canola Council of Canada (Winnipeg, Manitoba). From 1983 to 1991, prices were reported in dollars per bushel and were converted to dollars per tonne. Prices from 1991 to 1995 were reported in dollars per tonne. Canola oil prices prior to 1983 were indexed using the processed feed index.

Interest Rates

This study uses the 90-day treasury bill rate for Wednesdays as the risk free rate of interest. The 90-day treasury bill rate for each week from 1980 to 1995 was gathered from various issues of the Bank of Canada Review.

Exchange Rates

The Wednesday Canada/U.S. exchange rate for each week from 1980 to 1995 was collected from Thursday editions of the *Financial Post*. This rate reflects the closing rate for that particular day. The exchange rate was reported in units of number of Canadian dollars necessary to purchase one American dollar. These figures were then inverted to represent the number of American dollars necessary to purchase one Canadian dollar.

Price Indexes

Several price indexes were gathered to create representative time series of prices when actual data on those series were not available. The Consumer Price Index (1986=100) was obtained from various issues of the Bank of Canada Review. A veterinary services and drug supplies index, artificial insemination index, supplies and services index, farm input price index, labor index and prepared feed index (all 1986=100 for western Canada) were collected from the CANSIM database. These indexes were reported as monthly data and were interpolated to represent weekly price levels. All price series were then adjusted to 1995=100 to represent 1995 dollars.

Other Data

Veterinary services and drug supplies, trucking, marketing, utilities, maintenance, manure disposal, artificial insemination, rental, office and accounting, feed manufacturing, labor, salary, taxes and insurance, depreciation and land costs for the simulated hog farm were obtained from the "PorkPlan: Pork Production Cost and Financial Model, Version 1.0d." These costs were confirmed by a local producer and are found in Appendix A. The costs, excluding depreciation and land costs, were indexed with the appropriate price index to obtain a representative price series as follows:

Veterinary and drug supplies - veterinary services and drug supplies index
Trucking - supplies and services index
Marketing - supplies and services index
Utilities - consumer price index
Maintenance - supplies and services index
Manure Disposal - supplies and services index
Artificial Insemination - artificial insemination index
Rental - consumer price index
Office and accounting - consumer price index
Feed manufacturing - prepared feed index
Labor - labor index
Salary - labor index
Taxes and insurance - consumer price index
Depreciation and Land costs - amortized over 20 years at 10% interest

Feed Rations

Feed rations for the various types and weights of hogs were obtained from Gowans Feed Consulting of Red Deer, Alberta. The rations are as in Table 1 of Appendix A.

Animal Feed Requirements and Growth Performance

Feed requirements and growth performance for the feeder pigs in the operation were estimated from those in the "PorkPlan: Pork Production Cost and Financial Model, Version 1.0d." and appear in Appendix A. These daily rates of gain and feed conversions were then confirmed by a local producer and researcher (Perkins 1996; Aherne 1996).

Appendix C. ARIMA and Indexed Basis Forecasting Models

Autoregressive Integrated Moving Average (ARIMA) Model

ARIMA models are univariate time series models. They are constructed under observations of one variable through time, in this case the nearby hog basis. These models do not adhere to any conceptual economic framework, rather they are developed solely on describing processes at work within the series of observations that change the variable through time.

Several different ARIMA models were tested and analyzed to find the best ARIMA forecasting model. The optimal ARIMA model was found to be an ARIMA (1,0,1) X (1,0,1). This meant that the ARIMA model took the form:

$$HB_t = \delta + \alpha HB_{t-1} + \beta(HB_t - HB_{t-1}) + \gamma HB_{t-12} + \mu(HB_{t-12} - HB_{t-24}) + e_t$$

where: HB_i = nearby hog basis at time i

δ = an intercept term

$\alpha, \beta, \gamma, \mu$ = slope coefficients

e = error term

The results derived from testing the ARIMA (1,0,1) X (1,0,1) were:

Table 15. Test Statistics of ARIMA (1,0,1)X(1,0,1)

	Parameter	t-statistic*	Standard Error
AR (1)	0.83192	13.87	.5998E-01
MA (1)	0.39994	4.006	.9984E-01
SAR (1)	0.99163	102.4	.9688E-02
SMA (1)	0.76531	17.17	.4457E-01
CONSTANT	20464E-03	.9079	.2254E-03

* all coefficients significant at 95% confidence level

Q (36) = 35.82 Significance of Q = 0.294

where: AR=autoregressive
MA=moving average
SAR=seasonal autoregressive
SMA=seasonal moving average

Basis Index

One of the basis forecasting models used a three year average of the seasonalized nearby hog basis (Section 5.2.3.4). The indexed basis forecasting model was as follows:

$$IHB_t = \left[\frac{\left(\frac{HB_{t+25,YearX}}{HB_{Jan1,YearX}} \right)}{\left(\frac{HB_{t,YearX}}{HB_{Jan1,YearX}} \right)} \right]$$ This step indexes the nearby hog basis for seasonality.

$$IHBF_{t+25} = HB_t * \left(\frac{(IHB_{t-52} + IHB_{t-104} + IHB_{t-156})}{3} \right)$$ This step calculates the three year average of the seasonalized nearby basis.

where: HB_t = nearby hog basis at week t
IHB_t = indexed hog basis for week t+25 compared to basis at week t
$IHBF_t$ = indexed hog basis forecast at week t for week t+25

Appendix D.

Proof that $\ln\left(\frac{HF_{t,J+1}}{X_{t,J+1}}\right) \sim N\left[\left(\frac{\sigma_x^2}{2} - \frac{\sigma_s^2}{2}\right)(T-t), \left(\delta_{HF}^2 + \sigma_X^2 - 2\rho\sigma_{HF}\sigma_X\right)\right]$

(Unterschultz 1996)

Assumptions:
1. HF = futures price of commodity in U.S dollars
2. X = spot exchange rate in U.S. dollars to buy 1 Canadian dollar
3. Both prices have zero drift rate and are log normal

Then:

$$dHF = \sigma_{HF} HFdZ$$
$$dX = \sigma_X XdW$$

and let

$$dZdW = \rho dt$$

where ρ = correlation between $dZdW$

Let $G = \frac{HF}{X}$, which converts the futures price to Canadian dollars.

By Ito (see Hull, 1993),

$$dG = \frac{dG}{dt}dt + \frac{dG}{dHF}dHF + \frac{dG}{dX}dX + \frac{1}{2}\frac{d^2G}{dX^2}(dX)^2 + \frac{1}{2}\frac{d^2G}{dHF^2}(dHF)^2 + \frac{d^2G}{dHFdX}dHFdX$$

$$= \left(\frac{HF}{X}\sigma_X^2 - \frac{HF}{X}\sigma_{HF}\sigma_X\rho\right)dt + \frac{HF}{X}\sigma_{HF}dZ - \frac{HF}{X}\sigma_X dW$$

$$= G\left(\sigma_X^2 - \sigma_{HF}\sigma_X\rho\right)dt + G\left(\sigma_{HF}dZ - \sigma_X dW\right)$$

Show that G is log normally distributed,

$$Q = \ln G$$

then by Ito,

$$dQ = \left(\sigma_X^2 - \sigma_{HF}\sigma_X\rho - \frac{\sigma_{HF}^2}{2} - \frac{\sigma_X^2}{2} + \sigma_{HF}\sigma_X\rho\right)dt + \sigma_{HF}dZ - \sigma_X dW$$

$$= \left(\frac{\sigma_X^2}{2} - \frac{\sigma_{HF}^2}{2}\right)dt + \sigma_{HF}dZ - \sigma_X dW$$

and by $Q = \ln G$

$$\ln G_T \sim N\left(\left(\frac{\sigma_X^2}{2} - \frac{\sigma_{HF}^2}{2}\right)(T-t) + \ln G_t, \sqrt{\sigma_{HF}^2 + \sigma_X^2 - 2\rho\sigma_{HF}\sigma_X}\sqrt{T-t}\right)$$